



PARTS E1 to E5

PART F1

PARTS G1 to G5

PART H1

PART J1

Ed-Lab

Instructor's Manual

DC ELECTRONICS PARTS E1 to E5

MAGNETISM and MOTORS PART F1

AC ELECTRONICS PARTS G1 to G5

DIODES and POWER SUPPLIES PART H1

TRANSISTORS and CIRCUITS PART J1

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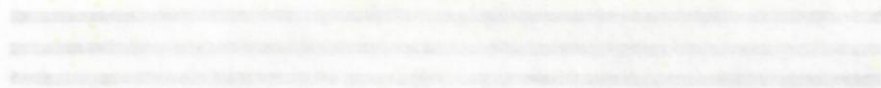
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PART 11

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Ed-Lab

Instructor's Manual

DC ELECTRONICS PARTS 12 OF 12
MAGNETISM and MOTORS PART 11
AC ELECTRONICS PARTS 10 OF 12
DIODES and POWER SUPPLIES PART 9
TRANSISTORS and CIRCUITS PART 8

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Ed-Lab Instructor's Manual

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Ed-Tab Instructor's Manual

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Ed-Lab 651

INSTRUCTOR'S GUIDE

MODULE 1 BASICS & DC CIRCUITS

CES INDUSTRIES, INC.



Ed-Lab 651
INSTRUCTOR'S GUIDE
MODULE 1: BASICS & DC CIRCUITS

Name _____
Class _____
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Ed-Lab 651

INSTRUCTOR'S GUIDE

MODULE 1 - BASICS & DC CIRCUITS

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ELECTRICITY - ELECTRONICS

CES ED-LAB 651

INSTRUCTOR'S GUIDE

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ELECTRICITY - ELECTRONICS

CEC 80-145 1st

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Ed-Lab 651

INSTRUCTOR'S GUIDE

MODULE 1 - BASICS & DC CIRCUITS

Ed-Lab 651

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MODULE 1 - BASIC & DC CIRCUITS

NOTE: * These resistor assortments may also be issued to a student loose, in a container. This approach, however, leads to losses and difficulty in checking and grading the answers in the experiment procedure.

It is suggested that the resistors be mounted on a board (perfboard or similar) as shown below in Figure 2 and marked. The answers will then be in an order that can be checked. Several cards can be prepared with a different order and resistance values.

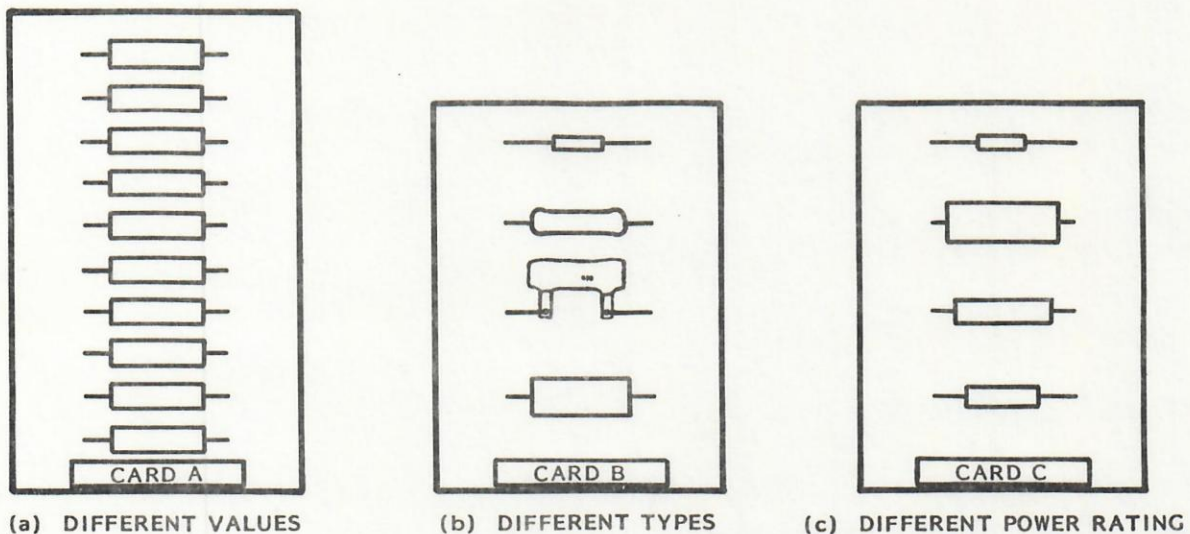


Figure 2 - Resistors.

CONSTRUCTION PROJECTS

In addition to performing the experiments in the Ed-Lab manuals, the students must gain experience in electronic assembly and construction using tools. This can be provided by a series of "Construction Projects or Kits" that would be assembled on: (a) prototype boards where the components are not soldered and are thus reusable or (b) hardwired, that is, soldered, which is the most trade-like and realistic approach. Since the parts when soldered are not easily reusable this approach results in a recurring cost.

Projects or Kits are not included in the Accessories to the 651. There is an experiment that does reference these projects and includes information for the following projects.

- a. Wire splicing
- b. Light blinker

These results show a significant increase in the rate of reaction in the presence of the catalyst. The reaction is first order with respect to the concentration of the reactant and zero order with respect to the concentration of the catalyst. The rate of reaction is also independent of the concentration of the product.

It is suggested that the reaction is catalyzed by a small amount of the reactant. The reaction is first order with respect to the concentration of the reactant and zero order with respect to the concentration of the catalyst. The rate of reaction is also independent of the concentration of the product.



Fig. 1. Effect of concentration on the rate of reaction.

CONCLUSION

The results of the experiments show that the reaction is catalyzed by a small amount of the reactant. The reaction is first order with respect to the concentration of the reactant and zero order with respect to the concentration of the catalyst. The rate of reaction is also independent of the concentration of the product.

These results are in good agreement with the theoretical predictions. The reaction is first order with respect to the concentration of the reactant and zero order with respect to the concentration of the catalyst. The rate of reaction is also independent of the concentration of the product.

These results are in good agreement with the theoretical predictions. The reaction is first order with respect to the concentration of the reactant and zero order with respect to the concentration of the catalyst. The rate of reaction is also independent of the concentration of the product.

Ed-Lab 651

INSTRUCTOR'S GUIDE

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Ed-Lab 651

INSTRUCTIONAL GUIDE

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NOTE: THIS LIST IS SUBJECT TO VARIATIONS.

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ED-LAB 651 and ACCESSORIES

1	Ed-Lab 651 Electronics Trainer
2 Packs	Pack of 20, (Red 1') Leads
1 Pack	Pack of 20, (Blue 2') Leads
2 Packs	Pack of 6, (Green 1') Stack Leads
2 Packs	Pack of 6, (Colors 2') Stack Leads
1 each	Earphone/Microphone
1 each	12AE6 Vacuum Tube
1 each	IC 741 Operational Amplifier
1 each	IC 555 Timer
1 each	IC 7473 Dual Flip-Flop
1 each	IC 7400 NAND (or 74L00 or 74LS00)
2 each	Set of Manuals
4 each	Alligator to Banana Adapters

NOTE: THIS LIST IS SUBJECT TO VARIATION

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All additional equipment required for some of the experiments in Module 1 are listed below grouped by units, E1 to E5.

UNIT E1 - D.C. ELECTRICITY CONCEPTS**EXPERIMENT NO. 3 - RESISTANCE MEASUREMENT**

- a. Analog VOM; Ohmmeter
- b. Digital VOM; Ohmmeter (Optional)
- c. Flashlight
- d. Three external components with resistance (Resistor, Coil, Relay, etc.)

UNIT E2 - D.C. ELECTRICAL CIRCUITS**EXPERIMENT NO. 7 - CIRCUIT CONTROLS**

- a. Flashlight

EXPERIMENT NO. 9 - ELECTRICAL MULTIMETERS

- a. Analog VOM; Multimeter
- b. Digital VOM; Multimeter

EXPERIMENT NO. 10 - TROUBLESHOOTING

- a. Analog or Digital VOM; Ohmmeter

EXPERIMENT NO. 11 - HAND TOOLS AND PROJECTS

- a. Splicing project (Optional)
- b. Electrical project (Optional)
- c. Electronic project (Optional)
- d. Appropriate hand tools

UNIT E3 - D.C. OHM'S LAW

EXPERIMENT NO. 14 - SOLVING OHM'S LAW FOR RESISTANCE

- a. Ohmmeter, Digital or Analog

EXPERIMENT NO. 15 - GRAPHING E-I CHARACTERISTICS

- a. Voltmeter, Digital or Analog

EXPERIMENT NO. 16 - RESISTOR COLOR CODE

- a. Resistor Card A (Different Values)
- b. Resistor Card B (Different types)
- c. Ohmmeter, Digital or Analog

EXPERIMENT NO. 17 - SERIES RESISTORS

- a. Ohmmeter, Digital or Analog

EXPERIMENT NO. 18 - POWER DISSIPATION

- a. 4 Banana Plug to Alligator Clip Adapters
- b. 1 1/4 Watt ohm resistor
- c. 1 1/2 Watt ohm resistor
- d. 1 Resistor Card C (Different Wattages)(Optional)
- e. Voltmeter, Digital or Analog (Optional)

UNIT E4 - D.C. CIRCUITS AND LAWS

EXPERIMENT NO. 22 - PARALLEL RESISTORS

- a. Digital or Analog Multimeter

EXPERIMENT NO. 25 - VOLTMETER CIRCUITS

- a. Digital or Analog Multimeter

EXPERIMENT NO. 28 - VOLTMETER LOADING

- a. Digital or Analog Multimeter

UNIT E5 - D.C. CIRCUITS AND THEOREMS

EXPERIMENT NO. 29 - MAXIMUM POWER TRANSFER

a. Digital Multimeter

UNIT 15 - D.C. CIRCLES AND TOWERS

EXERCISE NO. 15 - D.C. CIRCLES AND TOWERS

1. D.C. CIRCLES AND TOWERS

Listed below are several suitable texts that may be used with the CES electronic trainers. The books are listed in alphabetical order of the author's name. Many other books may be used as references.

Crozier, Patrick, Introduction to Electronics;
Breton Publishers, N. Scituate, Mass.

Floyd, Thomas L., Principles of Electric Circuits;
Charles E. Merrill Publishing Co, Colombus, OH

Fowler, Richard J., Electricity Principles and Applications;
McGraw Hill Book Co, New York, NY

Grob, Bernard, Basic Electronics;
McGraw Hill Book Co, New York, NY

The text correlation with each experiment is listed on the following pages.

<u>BOOK E1</u>	<u>Crozier</u>	<u>Floyd</u>	<u>Fowler</u>	<u>Grob</u>
Safety	p. 30-39		p. xi	
Info. Sheet 1 Matter	p. 55	p. 22	p. 3-5	p. 14-17
Info. Sheet 2 Atomic Structure		p. 22-23	p. 5-6	p. 15-17
Exp. No. 1 Basic Circuit		p. 36-37	p. 30	p. 28-31
Info. Sheet 3 Voltage Sources	p. 59-60		p. 17-19	p. 33-34
Exp. No. 2 Voltage Measurement	p. 90-91		p. 41	
Exp. No. 3 Resistance Measurement	p. 88-90, 118-119		p. 40-41	
Info. Sheet 4 Current Flow	p. 55-58	p. 24	p. 11-14	p. 22-26
Exp. No. 4 Current Measurement	p. 91-93		p. 42	p. 129-130
<u>BOOK E2</u>				
Exp. No. 5 Switch Circuits	p. 49	p. 41-43	p. 64-67	p. 343, 689-690
Exp. No. 6 Series and Parallel Circuits	Note 1			
Exp. No. 7 Circuit Control	Note 2			
Exp. No. 8 Voltages Aiding and Opposing		p. 101-103		
Exp. No. 9 Electrical Multimeters	p. 86-96		p. 37-45	p. 147-150
Exp. No. 10 Trouble- shooting Circuits	p. 120-125			
Exp. No. 11 Hand Tools and Projects	p. 127-131, 148-150			

CES ED-LAB 651

INSTRUCTOR'S GUIDE

MODULE 1 - BASICS & DC CIRCUITS

FOR STUDENT MANUALS E1, E2, E3, E4, E5

THE ED-LAB 651 SYSTEM

The Ed-Lab 651 is a comprehensive trainer covering electricity and electronics with basic, intermediate and advanced concepts. Components, power supplies, meters, and signal generators are all mounted on the panel for security, safety, and ease of use, and ease of management of components used in the experiments. Loose components are also used in the learning process as well as other external test instruments.

UNITS E1, E2, E3, E4 AND E5

BASICS & DC CIRCUITS

These units are the first to be covered in a standard electrical-electronics course and cover the topics for BASICS & DC CIRCUITS.

The E1, E2, E3, E4 and E5 series uses a lab-text format where experiments are also complemented with numerous information sheets. You could also use external reference texts as desired.

EXTERNAL TEST EQUIPMENT

The Ed-Lab 651 includes the power supplies and a built-in meter which can be used to measure DC voltage and current.

The equipment required to perform Module 1 is shown below.

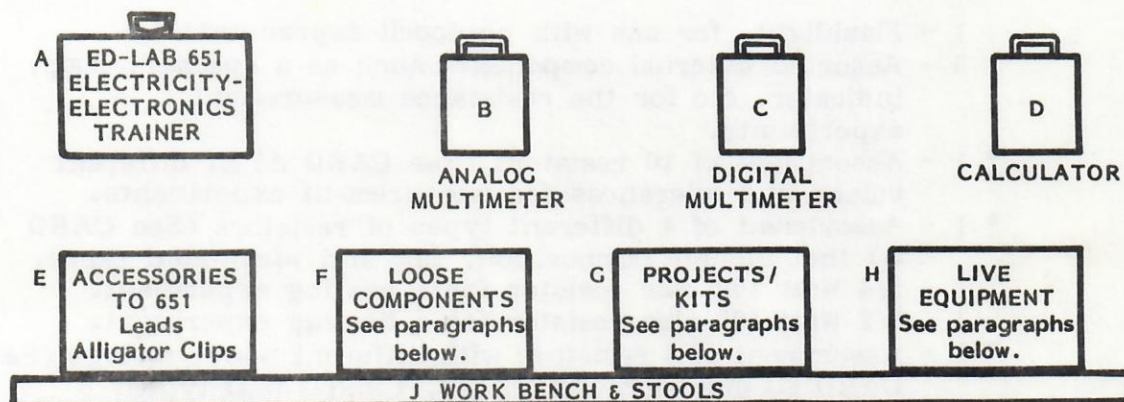


Figure 1 - MODULE 1 - DC; Equipment.

In addition to the Ed-Lab 651 (a) it is recommended that an analog multimeter (b) and a digital multimeter (c) be made available to the students. Several of the experiments require two meters and, also, they should gain experience in the use of instruments they will encounter in the field. A calculator (d) is also recommended. These units are:

- b. ANALOG MULTIMETER (CES 4070 or equal)
- c. DIGITAL MULTIMETER (CES 4024 or equal)
- d. CALCULATOR (CES 4080 or equal)

The Accessories to the 651 (e) needed for Module 1 consist of leads with banana plugs and four alligator clip adapters with insulating boots to connect external loose components. A full list of contents included with the Ed-Lab 651 package is given in Appendix A.

LOOSE COMPONENTS

A major feature of the Ed-Lab 651 is that components are mounted for security, safety and ease of management. However, the student must be able to work with components and electrical devices. This is accomplished by having the students work with the following external devices as well as performing experiments on the Ed-Lab 651 panel.

- a. Test Instruments/Meters
- b. External loose Components
- c. Projects and Kits
- d. Live electronics equipment.

Therefore, the student directions in Module 1/DC refers to components to be examined. These components are not provided in the Accessory package and the instructor can vary these parts used or cover these components in any other way.

The components that are referenced in Module 1 are listed below. These are not provided in the Accessory Package.

- 1 - Flashlight, for use with photocell experiments.
- 3 - Assorted external components such as a speaker, lamp, indicator, etc for the resistance measurement experiments.
- * 1 - Assortment of 10 resistors (See CARD A) of different values and tolerances for measurement experiments.
- * 1 - Assortment of 4 different types of resistors (See CARD B) that include composition, film and wirewound types.
 - 1 - 1/4 Watt 100 ohm resistor for a heating experiment.
 - 1 - 1/2 Watt 100 ohm resistor for a heating experiment.
- * 1 - Assortment of 4 resistors with different power ratings (See CARD C) one each of 1/4, 1/2, 1 and 2 watt types.

<u>BOOK E3</u>	<u>Crozier</u>	<u>Floyd</u>	<u>Fowler</u>	<u>Grob</u>
Exp. No. 12 Ohm's Law - Voltage	p. 99-102	p. 50-51, p. 56-60	p. 32-33	p. 39-43
Exp. No. 13 Ohm's Law - Current	p. 99-102	p. 50-51, p. 52-56	p. 32-33	p. 39-43
Exp. No. 14 Ohm's Law - Resistance	p. 99-102	p. 50-51, p. 60-62	p. 32-33	p. 39-43
Exp. No. 15 Graphing E-I Characteristics		p. 62-64		p. 43-45
Exp. No. 16 Resistor Color Code	p. 77-79	p. 29-30	p. 62-63	p. 230-231
Exp. No. 17 Series Resistors	p. 103-104	p. 90-92	p. 80	p. 54-58
Exp. No. 18 Power Dissipation	p. 101-102, 105-107	p. 72-77	p. 33-35	p. 48-49

BOOK E4

Exp. No. 19 Applications of Ohm's Law

Exp. No. 20 Kirchhoff's Voltage Law	p. 249	p. 104-107	p. 79-81	p. 163-164
Exp. No. 21 Voltage Dividers		p. 108-114	p. 83	p. 116-118
Exp. No. 22 Parallel Resistors	p. 118-194	p. 135-141	p. 86-91	p. 78-83
Exp. No. 23 Series-Parallel Circuits	p. 213-227	p. 172-115	p. 92-96	p. 91-97
Exp. No. 24 Kirchhoff's Current Law	p. 249	p. 146-150	p. 87	p. 161-162
Exp. No. 25 Voltmeter Circuits	p. 311-314	p. 663-667	p. 284-285	p. 135-140
Exp. No. 26 Ammeter Circuits	p. 314	p. 660-663	p. 280-281	p. 129-133
Exp. No. 27 Ohmmeter Circuits	p. 314-315	p. 669-671	p. 287-289	p. 142-147
Exp. No. 28 Voltmeter Loading		p. 665-667	p. 286	p. 138-142

<u>BOOK E5</u>	<u>Crozier</u>	<u>Floyd</u>	<u>Fowler</u>	<u>Grob</u>
Exp. No. 29 Maximum Power Transfer		p. 244-246	p. 85	
Exp. No. 30 Wheatstone Bridge		p. 201-203	p. 290	p. 100-101
Exp. No. 31 Superposition Theorem	p. 251-255	p. 221-228	p. 111-114	p. 175-184
Exp. No. 32 Thevenin's Theorem	p. 255-258	p. 229-237	p. 115-210	p. 177-184
Exp. No. 33 Norton's Theorem		p. 237-241	Note 3 p. 122-124	p. 184-188
Exp. No. 34 Delta-Wye Circuits		p. 247	Note 3 p. 157-158	p. 193-195

NOTES:

1. Experiment No. 6, Series and Parallel Circuits, is a non-mathematical introduction to the circuits. All four of the reference texts start with only a mathematical approach so that the reading assignments are not given at this time but are given in two experiments which cover Series and Parallel Circuit mathematics.
2. An elementary introduction to circuit controls using a transistor is given in Experiment 7 and is not covered at this level in any of the texts.
3. This discussion refers to Delta and Wye configurations for power distribution only and is not totally applicable.

The following section contains the answers to the text-lab manuals in Module 1 - DC.

The manuals included are:

- Unit E1 - DC Electricity Concepts
- Unit E2 - DC Electrical Circuits
- Unit E3 - DC Ohm's Law
- Unit E4 - DC Circuits & Laws
- Unit E5 - DC Circuits & Theorems

The following information is provided for the
purpose of the study.

The following information is provided:

- Unit 1 - DC Security Council
- Unit 2 - DC Security Council
- Unit 3 - DC Security Council
- Unit 4 - DC Security Council
- Unit 5 - DC Security Council
- Unit 6 - DC Security Council
- Unit 7 - DC Security Council
- Unit 8 - DC Security Council
- Unit 9 - DC Security Council
- Unit 10 - DC Security Council

Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

D.C. ELECTRICITY CONCEPTS

UNIT E1

Ed-Lab-821

INSTRUCTOR'S ANSWER MANUAL

D.C. ELECTRICITY CONCEPTS

UNIT 21

Unit E1 - DC ELECTRICITY CONCEPTS

INSTRUCTOR'S ANSWER MANUAL

SAFETY LESSON

ASSIGNMENT:

1. A. Turn off power and remove victim.
B. Loop a jacket or shop apron around the victim and pull him/her off the voltage source.
2. A. Electrical Shock
B. Electrical Fire
C. Hand Tool Injury
3. A. 6
B. 8
C. 7
D. 1
E. 3
F. 1, 4, 5
G. 2
H. 4
4. A. F
B. T
C. F
D. F
E. T

INFORMATION SHEET 1 - STRUCTURE OF MATTER

ASSIGNMENT:

1. d. all of the above.
2. a. steel.
3. d. all of the above.
4. b. compounds.
5. c. The smallest unit of a compound that still retains the compound's characteristics.

INFORMATION SHEET 2 - ATOMIC STRUCTURE

ASSIGNMENT:

1. a. atom.
2. c. protons and neutrons.
3. b. positively charged.
4. a. negative.
5. d. all of the above.
6. c. Ring 1 = 2, Ring 3 = 18, Ring 5 = 32.
7. c. 8 electrons, maximum.
8. a. 26.
9. a. 72 times more weight than a hydrogen atom.
10. d. all of the above.
11. c. is a positive ion.
12. d. any of the above.
13. b. lower its energy level.
14. a. free electron.
15. d. all of the above.

EXPERIMENT NO. 1 - BASIC ELECTRICAL CIRCUIT

QUESTIONS:

3. Turn the trainer power switch on the left side of the panel to ON (UP).

Does the lamp light? Yes

4. Remove the wire (Y) that connects the lamp to the negative terminal of the voltage source.

Does the lamp still light? No

6. Remove the wire (X) that connects the lamp to the positive terminal of the voltage source.

Does the lamp still light? No

8. Turn the trainer power On and place Switch A UP.

Is the lamp ON or OFF? On

9. Set Switch A DOWN.

Is the lamp ON or OFF? Off

Does the lamp glow when the electron flow is ON or OFF? On

11. Operate switch A UP and DOWN as before.

Does the lamp light when the switch is UP or DOWN? Down

Is this different than before? Yes

15. Operate the switch.

What is the result? Turns lamp on and off

ASSIGNMENT:

1. c. a voltage source.
2. b. not glow.
3. d. none of the above.

4. Source

d. Battery

Connections

a. Wires

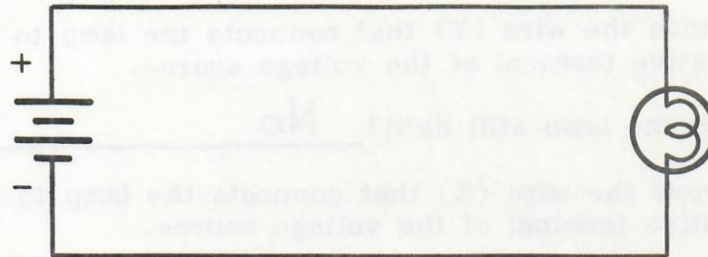
Load

b. Lamps

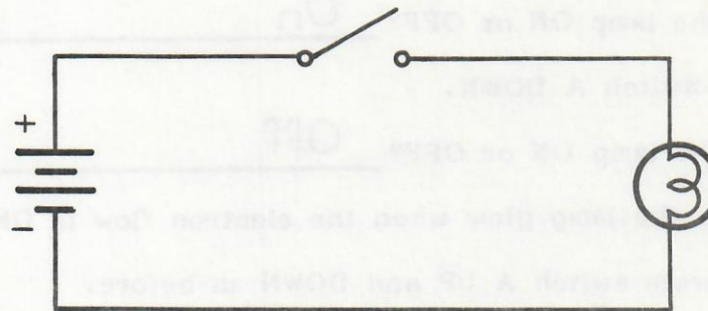
Control

c. Switch

5.



6.



INFORMATION SHEET 3 - VOLTAGE SOURCES

ASSIGNMENT:

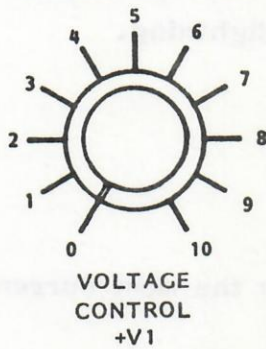
1. d. all of the above.
2. d. all of the above.
3. a. can be dangerous in the form of lightning.
4. b. is not intended to be recharged.
5. a. are able to be recharged.
6. d. all of the above.
7. c. D cell is the largest and provides the most current flow of the three sizes.
8. c. alkaline manganese equals the zinc carbon.
9. d. all of the above.
10. a. magnetic induction.
11. b. heat measuring instruments.
12. d. all of the above.
13. b. are used to generate electricity when exposed to a light source.
14. c. wired in banks to supply higher.
15. j
b g
a b
f
b k
d h l
e
c
i

EXPERIMENT NO. 2 - VOLTAGE MEASUREMENT

QUESTIONS:

3.

(NUMBERS NOT
MARKED ON PANEL)



+V1 VOLTAGE CONTROL SETTINGS	+V1 VOLTAGE OUTPUTS
0	0 V.
5	4.0 V.
10	9.0 V.

TABLE 2 - Output voltage from +V1.

4. Does the voltage vary gradually or in sharp steps as the Voltage Control is moved? Voltage varies gradually

5.

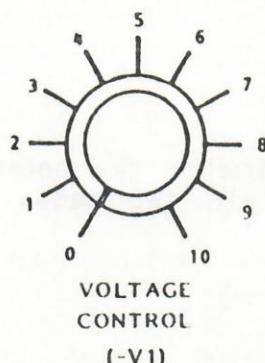
VOLTAGE SOURCE	OUTPUT VOLTAGE
+V2	9.0 V.
+V3	5.0 V.

TABLE 3 - Output voltages from +V2 and +V3.

6. What has the meter pointer done? Deflects to the left of zero

Do you think that it is possible to measure voltage when the polarity of the meter is reversed? No

7.



-V1 VOLTAGE CONTROL SETTINGS	-V1 VOLTAGE OUTPUTS
0	0 V.
5	-4.0 V.
10	-9.0 V.

TABLE 4 - Output voltage from -V1.

8.

VOLTAGE SOURCE	OUTPUT VOLTAGE
-V2	-9.0 V.
-V3	-9.0 V.

TABLE 5 - Voltage source measurements.

Do all the voltage sources provide the correct voltages? Yes

11.

SWITCH A	SOURCE +V2	V LAMP	LAMP ON OR OFF
UP	9.0 V	9.0 V	ON
DOWN	9.0 V	0 V	OFF

TABLE 6 - Circuit voltage measurements.

12. What is the voltage across the lamp with Switch A DOWN? 0 volts

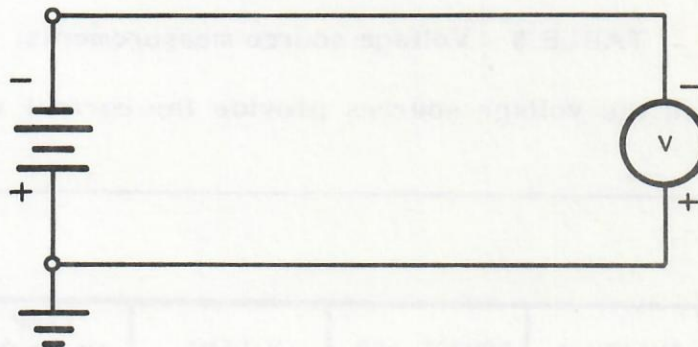
Does the lamp light? No

Why? Power source is disconnected

ASSIGNMENT:

1. d. all of the above.
2. c. 2,200 volts = 2.2 kV.
3. a. 5 mV.
4. b. When measuring voltage with a voltmeter, the meter must be connected into the circuit with two leads.
5. b. 11 V.
6. d. none of the above.
7. d. all of the above.
8. a. UP, the lamp voltage will read 9 V.
9. 4,700 Volts
1/2 Volt
Potential Difference
voltmeter
4.7 millivolts
- d. 4.7 kV.
b. 500 mV.
e. emf
c. 
a. 0.0047 V.

10.



EXPERIMENT NO. 3 - RESISTANCE MEASUREMENT

QUESTIONS:

2.

METER TYPE	<u>Electronic Multimeter</u>
MANUFACTURER	<u>CES Industries, Inc.</u>
MODEL NUMBER	<u>CES 4007</u>

9. Did you hear the sounds? Yes

10. In Measurements 13 and 14 in Table 1, your body resistance, which gave the lowest resistance reading, the wet or dry condition? Wet

A	B	C	D
COMPONENT	MULTIPLIER SETTING	METER READING	RESISTANCE VALUE
1. 100 (Left)	X1	100	100Ω
2. 1K (Left)	X10	100	1000Ω
3. 3.3 K (Left)	X100	32	3.2 K
4. 10 K (Left)	X1K	9.5	9.5 K
5. 33 K (Left)	X1K	32	32 K
6. 33 K (Right)	X1K	33	33 K
7. 470 K	X10K	45	450K
8. 1 M	X100K	9.6	0.96M
9. 4.7 M	X1M	4.6	4.6 M
10. LAMP 1	X1	25	25 Ω
11. 50 mH coil	X1	62	62 Ω
12. Speaker	X1	8	8 Ω
13. Between Fingers (Dry)	X10K	30	300 K
14. Between Fingers (Wet)	X10K	10	100K

TABLE 1 - Resistance measurements.

11. How do the measured resistor values in Column D compare with the values printed on the panel? They are very

close (within the specified tolerance.)

12.

COMPONENT DESCRIPTION	MULTIPLIER SCALE	METER READING	RESISTANCE VALUE
1. Resistor	XIK	9.7	9.7K
2. Microphone	XIK	2.0	2.0K
3. Speaker	XI	2.5	2.5 Ω

TABLE 2 - External component resistance readings.

13.

10 K POT	MULTIPLIER SETTING	METER READING	RESISTANCE VALUE
TOTAL R KED to BLACK	XIK	10.05	10.05 K
PARTIAL RESISTANCES, POSITIONS 0 TO 10			
0	XIK	0.2	200 Ω
1	XIK	1.2	1.2 K
2	XIK	2.2	2.2 K
3	XIK	3.4	3.4 K
4	XIK	4.6	4.6 K
5	XIK	5.5	5.5 K
6	XIK	6.6	6.6 K
7	XIK	7.7	7.7 K
8	XIK	8.6	8.6 K
9	XIK	9.8	9.8 K
10	XIK	10.05	10.05

TABLE 3 - Potentiometer resistance readings.

14.

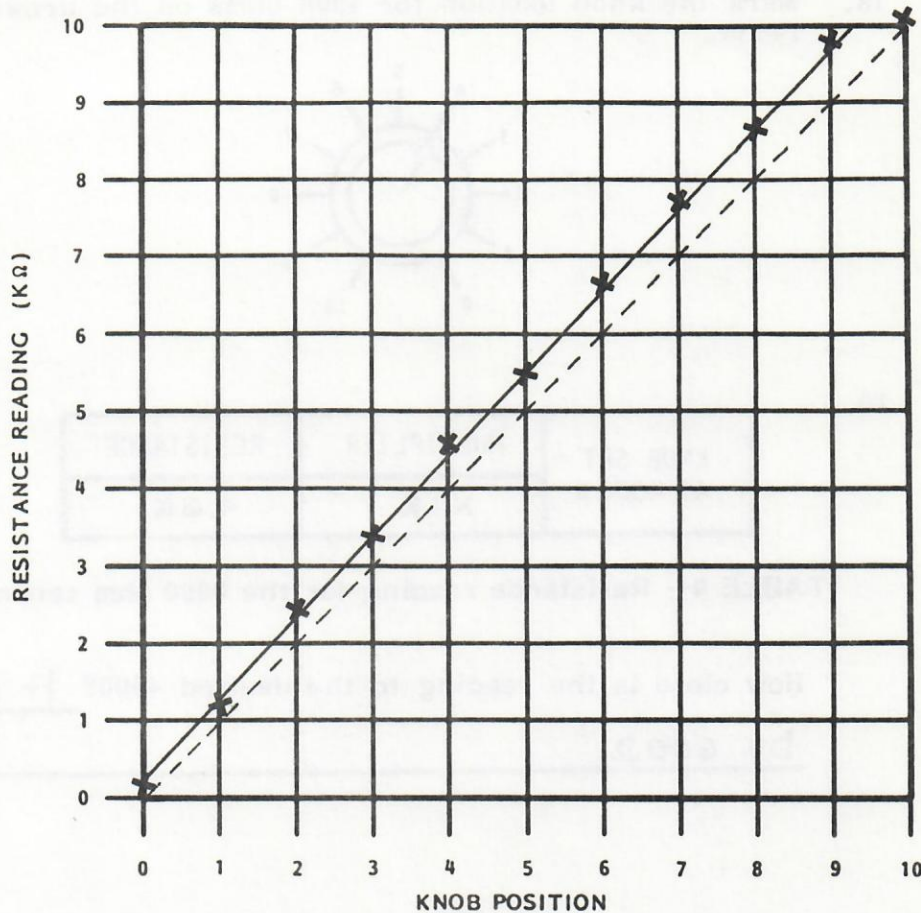


Figure 7 - Plot of the Resistance versus Knob settings.

15. How do your readings compare with those expected? Do the plot points indicate good linearity? Explain the reasons for any non linearity. May be off at top and bottom positions due to end resistance of the potentiometer. May be slightly nonlinear at center due to manufacturing tolerances. The ideal response is indicated in dashed line.

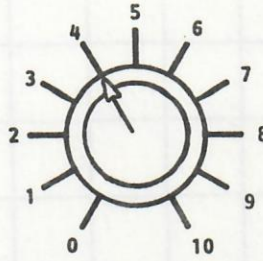
16.

KNOB SET AT 8	MULTIPLIER	RESISTANCE
	X1K	1.7K

TABLE 4 - Pot resistance from Yellow to Red terminals.

17. Did the resistance reading in Step 16 produce the expected value? No, if you expected 8K;
Yes, if you expected 2k.

18. Mark the knob location for 4000 ohms on the drawing below.



- 19.

Knob Set at 4000 Ω	Multiplier	Resistance
	$\times 1K$	4.6 K

TABLE 4 - Resistance reading for the 4000 ohm setting.

How close is the reading to the desired 4000? It is off
by 600 Ω

- 20.

Light Conditions	Resistance
Ambient Light	5.5 K
Hand shading cell 5" away	20 K
Hand covering cell (dark res.)	400 K
Flashlight on cell (light res.)	300 Ω

TABLE 6 - Photocell resistance readings.

Note: Readings obtained may vary depending on the ambient light conditions.

21. What are the High and Low photocell resistance values?

HIGH =	400 K	Ω
LOW =	300	Ω

Calculate the Resistance Ratio from

$$\text{Resistance Ratio} = \frac{R \text{ High } 400K \ \Omega}{R \text{ LOW } 300 \ \Omega}$$

$$\text{Resistance Ratio} = \frac{400,000}{300} = 1,333 : 1$$

Note that the ratio has no unit; it is just a number.

- 22.

METER TYPE	Digital Multimeter
MANUFACTURER	CES Industries, Inc.
MODEL NUMBER	CES 4025

- 23.

COMPONENT	MEASURED RESISTANCE
100 (Left)	100.7 Ω
1 K (Left)	994 Ω
15 K	15.14 K
100 K (Left)	100.8 K
4.7 M	4.75 M

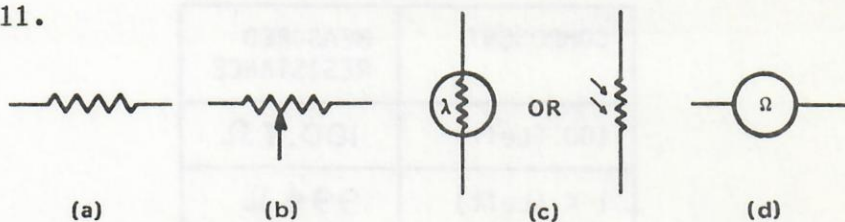
TABLE 7 - Digital meter resistance measurements.

24. What comments do you have on the differences between the Analog and Digital Ohmmeters?

The digital meter is easy to read and is more accurate.

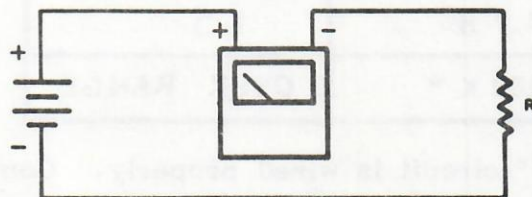
ASSIGNMENT:

1. a. electrons.
2. b. 5 K.
3. d. all of the above.
4. d. all of the above.
5. c. zero ohms on the right, infinity on the left.
6. d. all of the above.
7. F The resistance of a potentiometer varies when the shaft is rotated.
8. T
9. T
10. T
- 11.

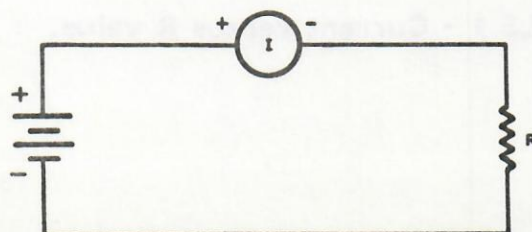


1. d. 6.25×10^{18} electrons passing a given point in a conductor constitutes a charge of 1 coulomb.
2. d. all of the above.
3. a. The electron theory states that negative charges flow from minus to plus.
4. d. 15.63×10^{18} electrons.
 $2.5 \times 6.25 \times 10^{18} = 15.625 \times 10^{18} \cong 15.63 \times 10^{18}$.
5. d. all of the above.
6. b. 1.86×10^5 miles per second = 186,000 mps.
7. a. When measuring current an ammeter must be placed across a break in the circuit.
8. d. none of the above.
9. a. increased using a shunt resistor.
10. 2 A e. 2,000 mA
0.5 A c. 500,000 uA
50 mA d. 0.05 A
100 μ A g. 0.1 mA
5 μ A a. 0.005 mA
1,000 nA b. 0.001 mA

11.



OR



EXPERIMENT NO. 4 - CURRENT MEASUREMENT

QUESTIONS:

7.

METER READING	$I_{LAMP} = \underline{39.0} \text{ mA}$
------------------	--

8. Vary the +V1 Voltage Control knob counterclockwise.

What happens to the brightness of the lamp and the current readings? The current reading

decreases and the lamp intensity
also decreases.

9.

METER READING	$I_{LOW} = \underline{20.0} \text{ mA}$
------------------	---

11.

RESISTOR R	CURRENT, μA
470 K	18.0
1 M	9.0
4.7 M	1.5
100 K *	OVER RANGE

* Meter will "peg;" circuit is wired properly. Continue to next step.

TABLE 1 - Current versus R value.

13.

RESISTOR R	CURRENT mA
100 K	0.1
56 K	0.15
33 K	0.25
15 K	0.55
10 K	0.9
4.7 K	1.85
3.3 K	2.7
2.2 K	4.1
1 K	9.7

TABLE 2 - Current measurements.

15.

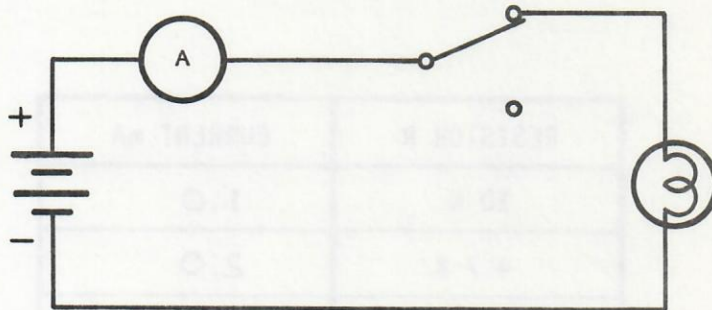
RESISTOR R	CURRENT mA
10 K	1.0
4.7 K	2.0
2.2 K	4.0
1 K	9.0
100 *	90
LAMP 1	41.0

* Change to 100 mA shunt (T1 - T2) before applying power.

TABLE 3 - Current measurement.

ASSIGNMENT:

1. a. electron flow.
2. d. all of the above.
3. d. all of the above.
4. b. lowering the circuit resistance.
5. c. positive terminal of the milliammeter is connected to the positive terminal of the voltage source.
6. F One milliampere equals 1/1000 of an ampere or 0.001 A.
7. T
8. T
9. F If a current meter pointer slams backwards, the meter polarity is reversed.
10. T
- 11.



Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

D.C. ELECTRICAL CIRCUITS

UNIT E2

Ed-Lab-651

INSTRUCTIONS ANSWER MANUAL

D.C. ELECTRICIAN CIRCUITS

PART 11

Unit E2 - DC ELECTRICAL CIRCUITS

INSTRUCTOR'S ANSWER MANUAL

EXPERIMENT NO. 5 - SWITCH CIRCUITS

QUESTIONS:

3.

SWITCHES		LAMP ON/OFF
SA	SB	
DOWN	DOWN	off
DOWN	UP	off
UP	DOWN	off
UP	UP	On

TABLE 1 - AND switch circuit performance.

4. How many switch combinations caused the lamp to light? one

7.

SWITCHES		LAMP ON/OFF
SA	SB	
DOWN	DOWN	off
DOWN	UP	On
UP	DOWN	On
UP	UP	On

TABLE 2 - OR switch circuit performance.

8. How many switch combinations caused the lamp to light? three

11.

SWITCHES		LAMP ON/OFF
SA	SB	
DOWN	DOWN	On
DOWN	UP	Off
UP	DOWN	Off
UP	UP	On

TABLE 3 - Three-way switch circuit performance.

12. How many switch circuit combinations caused the lamp to light? two

15.

SWITCHES			LAMP ON/OFF
SA	SB	SC	
DOWN	DOWN	DOWN	Off
DOWN	DOWN	UP	On
DOWN	UP	DOWN	Off
DOWN	UP	UP	On
UP	DOWN	DOWN	Off
UP	DOWN	UP	On
UP	UP	DOWN	On
UP	UP	UP	On

TABLE 4 - AND-OR switch circuit performance.

16. How many switch combinations caused the lamp to light? five

Why is this circuit called AND-OR control? Switches A and B can light the lamp OR switch C by itself.

18.

STEP	CONDITION	SA	SC	VALVE L1	HEATER L2
1	SYSTEM OFF	DOWN	DOWN	Off	Off
2	START, ON, VALVE OPEN	UP	DOWN	On	Off
3	FILLED-VAT, HEATER ON VALVE OFF	UP	UP	Off	On
4	TEMPERATURE AT DESIRED VALUE	DOWN	UP	Off	Off
5	SYSTEM RETURN TO OFF	DOWN	DOWN	Off	Off

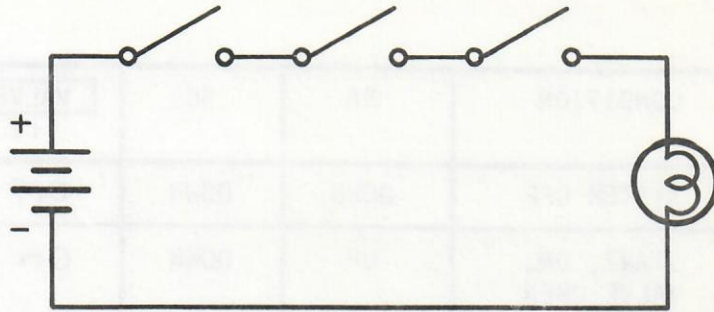
19. How many different conditions or switch arrangements are there with these two lamps in the circuit? four

How many result in a lamp being On? two

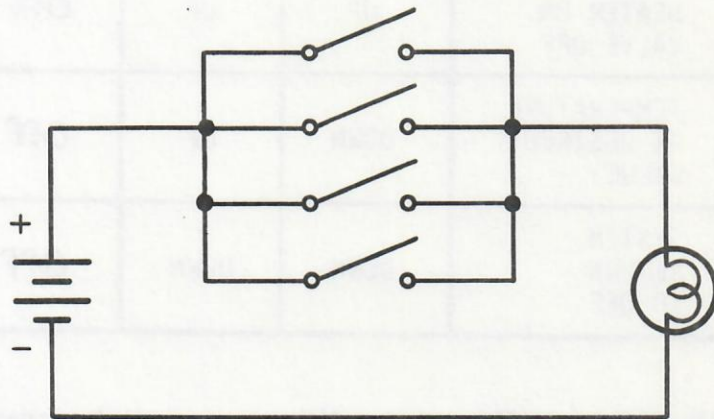
ASSIGNMENT:

1. F Both switches must be closed to provide a complete circuit to power the lamp.
2. F Either switch A or B, when closed, will power the lamp.
3. T
4. T
5. T
6. F Either Switch A or B can be reset to power the lamp.

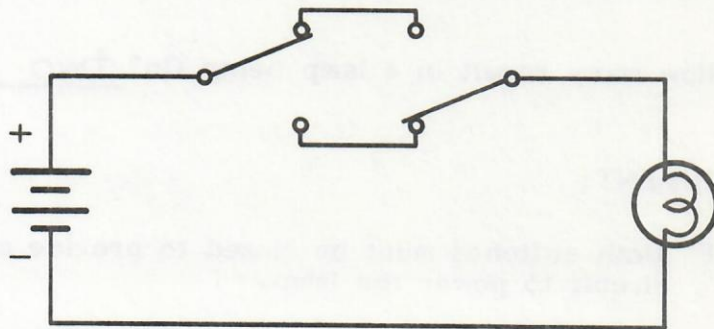
7.



8.



9.



EXPERIMENT NO. 6 - SERIES AND PARALLEL CIRCUITS

QUESTIONS:

3. Do both lamps light? Yes
Do both lamps glow with the same intensity? Yes
Do both lamps light at full intensity? No
4. Record the current flow indicated by the meter.

I series = 27 mA

5. Disconnect the meter from the circuit by removing the leads connecting the meter + terminal to the switch and the meter - terminal to Lamp 1.

Do the lamps still light? No
Why? The series circuit is now broken.

8. Record each current reading in Table 1.

CHECK POINT	CURRENT mA
A	27
B	27
C	27
D	27

TABLE 1 - Series circuit current measurements.

9. Compare the four current readings in Table 1. Are they the same? Yes

Should the currents be the same? Yes

Are the Table 1 current readings the same as that made in Step 4? Yes

Can you conclude from the above that the current is the same at all points in a series circuit? Yes

10. Break the series circuit by removing one wire at a time and replacing it again.

What happens to the lamps when each wire is removed? The lamp turns off.

What can you conclude from this step? The lamp turns off when any one of the series wires are disconnected.

12. Apply power and set Switches, A, B and C UP.

What is the state of each lamp (ON or OFF)? Both lamps are off.

- 13.

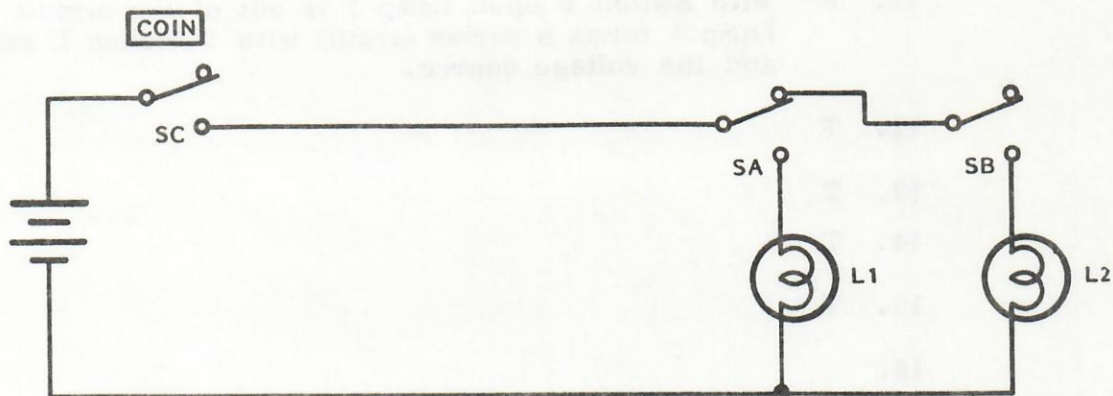
	SWITCHES			CURRENT IT, mA	SERIES, PARALLEL OR OPEN	FUNCTION
	COIN C	COIN A	COIN B			
1.	UP	UP	UP	0	Open	STAND BY
2.	UP	UP	DOWN	0	Open	SELECT COLA
3.	UP	DOWN	UP	0	Open	SELECT ORANGE
4.	UP	DOWN	DOWN	0	Open	SELECT BOTH
5.	DOWN	UP	UP	0	Open	COIN IN
6.	DOWN	UP	DOWN	40	Series	SELECT COLA
7.	DOWN	DOWN	UP	40	Series	SELECT ORANGE
8.	DOWN	DOWN	DOWN	80	Parallel	SELECT BOTH

TABLE 2 - Data for Figure 7.

Which circuit condition (Switches C, A, and B UP or DOWN) refers to the COLA operation and which refers to the ORANGE operation? A Up, B Down, C Down

refers to Cola. A Down, B Up, C Down
refers to Orange.

14. Can you think of a circuit arrangement so that cola and orange cannot be both selected together but any one can be selected at a time?



16. Apply power and operate Switch SA.

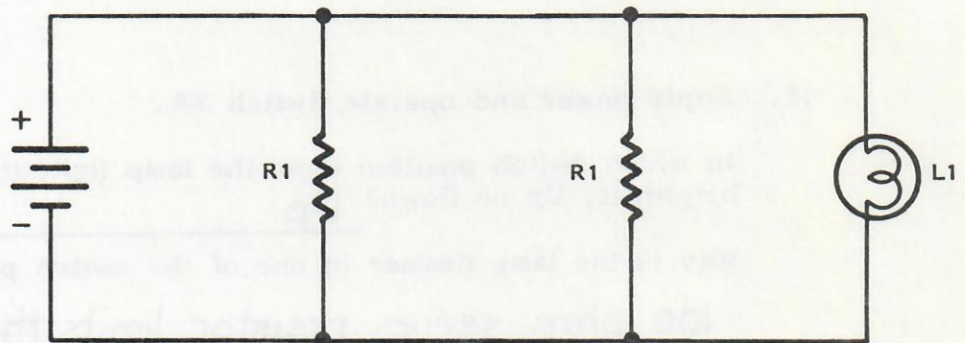
In which switch position does the lamp light the brightest, Up or Down? Up

Why is the lamp dimmer in one of the switch positions? The 100 ohm series resistor limits the current.

ASSIGNMENT:

1. b. is never more than one current path.
2. d. exactly equal to the current flowing at any point in the circuit.
3. a. current to stop flowing everywhere in the circuit.
4. a. sum of the branch currents.
5. b. in parallel with the meter.
6. T
7. T
8. F Neither lamp will light as all current will flow through the wire.

9. F This is a series circuit and the current is the same at every point.
10. T
11. F With Switch B open Lamp 2 is out of the circuit and Lamp 1 forms a series circuit with Switches C and A and the voltage source.
12. T
13. T
14. T
15. T
- 16.



EXPERIMENT NO. 7 - CONTROL CIRCUITS

QUESTIONS:

3. Does the lamp intensity increase with CW or CCW rotation? CCW

4. Does the lamp intensity increase with CW or CCW rotation? CW

5.

R pot = 400 Ω .

7. Apply power and observe the lamp when the photocell is exposed only to the "ambient" or room light.

Is the lamp On or Off? Off

8. Explain why the lamp behaves as it does. The photocell with existing ambient light has a high resistance.

9. Use an external flashlight to illuminate the photocell as shown in Figure 5.

How far from the photocell do you have to place the flashlight in order to turn the lamp On? 3"

10. Why is the lamp turned on when the photocell is illuminated? The photocell resistance reduces when illuminated and causes the lamp to turn on.

11. Does any position of the flashlight cause the lamp to light at full intensity? No

Explain why. Even with full illumination the photocell resistance is not low enough for the lamp to glow at full intensity.

13. Is the lamp On or Off? Off

16. Apply power. Is the lamp On or Off? On

17. Does the lamp shut Off? Yes

18. Remove your finger from the photocell. Wave your hand in front of the photocell. Can you control the lamp intensity by hand movement? No

20. Adjust the 1 K pot until the lamp is ON but just "on the verge" of going OFF.

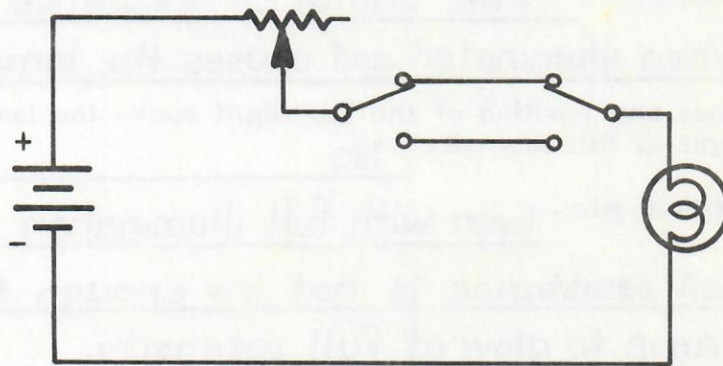
Now, wave your hand in front of the photocell. How well can you control the lamp intensity? The lamp can now be turned on and off by waving the hand.

22. Use the flashlight to turn the lamp On.

How far away can you stand and still control the lamp with the flashlight? 20 feet

ASSIGNMENT:

1. c. the lamp intensity to be decreased by clockwise rotation of the pot knob.
2. c. not glow at all.
3. d. none of the above.
4. b. not light when +V2 is On.
5. c. barely light when the photocell is exposed to ambient light.
6. d. all of the above.
- 7.



EXPERIMENT NO. 8 - VOLTAGES AIDING & OPPOSING

QUESTIONS:

2.

$$E_T = \underline{14} \text{ V}$$

Is the sum of the two voltages the expected value? Yes

4.

$$E_T = \underline{4} \text{ V}$$

Is the resultant voltage as expected? Yes

6.

$$E_T = \underline{4} \text{ V}$$

POLARITY A + B -

Are the voltage and polarity as expected? Yes

7. What was the effect on the voltmeter? The voltmeter pointer swung below zero.

Why did this happen? The resultant voltage was now negative.

ASSIGNMENT:

1. d. any of the above.

2. b. 10 V, A+ B-

$$5 + 10 + 3 - 8 = 10 \text{ V}$$

3. d. 2 V, D+ B-

$$10 - 8 = 2 \text{ V}$$

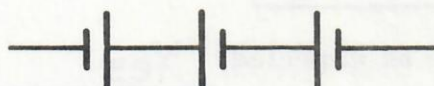
4. c. 7 V, A- D+

$$5 + 10 - 8 = 7 \text{ V}$$

5. d. all of the above.

- a. D to E -3 V directly
b. D to A $5 + 10 - 8 = 7 \text{ V}$
c. D to B $10 - 8 = +2 \text{ V}$

6. b. light dimly.



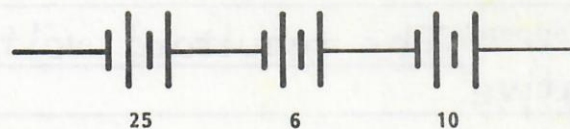
$$1.5 + 1.5 - 1.5 = 1.5 \text{ V}$$

7. A.



$$25 - 12 + 10 = 23 \text{ V}$$

- B.



$$25 + 6 + 10 = 41 \text{ V}$$

EXPERIMENT NO. 9 - ELECTRICAL MULTIMETERS

QUESTIONS:

3.

R RESISTOR	RANGE	SCALE READING	VOLTAGE VALUE
100 Ω	0.25	1.0	0.100 V
2.2 K	5.00	2.3	2.3
15 K	25.00	1.55	15.5

TABLE 1 - Voltage readings with an Analog VOM.

8.

R RESISTOR	RANGE	READING	CURRENT VALUE
* 100 Ω	250	1.25	125 ma
1 K	25	1.8	18 ma
15 K	2.5	1.2	1.2 ma
33 K	2.5	0.5	0.5 ma

TABLE 2 - Current readings with an Analog VOM.

* Note: The current through the 100 ohm resistor in steps 8 and 12 should actually be 180 ma, but the internal power supply protection limits it to about 125 ma.

11.

R RESISTOR	RANGE	VOLTAGE READING
100 Ω	200 mV	102.7
2.2 K	20 V	2.31
15 K	20 V	15.57

TABLE 3 - Voltage readings with a Digital VOM.

12.

R RESISTOR	RANGE	CURRENT READING
100 Ω	200 ma	12.5
1 K	20 ma	17.84
15 K	2 ma	1.195
33 K	2 ma	0.541

TABLE 4 - Current readings with a Digital VOM.

13. Compare the analog and digital meters for the following:

Ease of use - The digital meter is easier to use.

Speed of operation - The digital meter responds to changes faster, but with the analog meter it is easier to observe changes due to gradual movement of the pointer.

Accuracy of reading - The digital meter is more accurate than the analog meter.

Ease of reading the scales - The digital meter is preferred since there is only one "scale" or reading.

Polarity reversal problems - The digital meter is better since it has "auto polarity."

Overloading the meter range - The analog meters are delicate and susceptible to damage from overload; digital meters are better in that respect.

17. Grasp leads A and B between the thumb and forefinger of each hand. Apply different pressures; what are your observations? The intensity of the lamp increases as the leads are gripped harder.

18.

TEST POINT		VOLTAGE
SUPPLY	TP 1	9.05 V
LAMP	TP 2	9.05 V
COLLECTOR	TP 3	7.60 V
BASE	TP 4	1.73 V
EMITTER	TP 5	1.42 V

TABLE 5 - Voltage chart for the circuit of Figure 5.

How do the voltages in Table 5 compare to the expected voltages listed in Figure 5? The voltages of

Table 5 compare favorably with those listed in Figure 5.

ASSIGNMENT:

1. F One must start at the highest voltage range and lower it as necessary.
2. T
3. F The scale cannot be read because the pointer slams backwards.
4. F Polarity reversal causes a (-) to appear.
5. T
6. F The digital meter is more accurate. It can be read to three significant places.
7. T
8. F Both digital and analog meters must be placed in series when measuring current.
9. T
10. T

EXPERIMENT NO. 10 - TROUBLESHOOTING CIRCUITS

QUESTIONS:

2. Does the lamp light? Yes

3.

TEST POINT	VOLTAGE READINGS			
	N NORMAL	OPEN I	OPEN II	OPEN III
1	9.0V	9V	9.0V	9.0V
2	9.0V	0V	9.0V	9.0V
3	9.0V	0V	9.0V	9.0V
4	9.0V	0V	9.0V	9.0V
5	9.0V	0V	0V	9.0V
6	9.0V	0V	0V	9.0V
7	9.0V	0V	0V	9.0V
8	9.0V	0V	0V	9.0V
9	0V	0V	0V	0V

TABLE 2 - Checkpoint voltages for normal and open circuits.

- I. Leads from battery to Switch A open.
- II. Switch B open.
- III. All voltages are normal but the lamp does not glow indicating an open lamp.

8.

SWITCH STATE	OPEN	CLOSED
E SWITCH C	<u>9.0</u> V	<u>0</u> V

9. What is your observation about the voltage drop across the open in a series circuit? The full supply

voltage appears across an open in a series circuit.

10.

$E_{SA} = $ <u>0</u> V	$E_{SC} = $ <u>0</u> V
------------------------	------------------------

Is measuring voltage across a component a decisive test procedure when looking for an open circuit? No

ASSIGNMENT:

1. a. no current will flow.
2. b. 0 mA.
3. d. any of the above.
4. c. the wire EF is open.
5. c. voltages at points A and B will be 10 Volts with respect to point J.
6. a. not always a reliable test.

EXPERIMENT NO. 11 - HAND TOOLS AND PROJECTS

QUESTIONS:

15. Have your instructor examine the project. What improvements or corrections did he suggest? a) Wires
dressed square and close to the board.
b) Reheat cold solder joints.
c) Insulation too close to the solder joint
17. Operate the circuit switches. Record your observations and comments on the construction and operation of the project. Construction is on a perfboard using
two SPDT toggle switches, a 100 ohm
resistor and an incandescent lamp. This
is wired as an On-Off High-Low control
system.
The circuit operation is as follows:
1) Switch A has to be on for the lamp to
glow.
2) Switch B up, lamp glows brightly.
3) Switch B down, lamp glows dimly.
18. Switch Type - Toggle switch (typical)
19. Describe the lamp type used in the project.
Incandescent (typical)
20. Describe the type of wire used in the project.
Copper #22 (typical)
21. Describe the type of solder used in the project.
60/40 (60% tin, 40% lead)

ASSIGNMENT:

1. a, g
l
a
b, f
h
d
e
j
i
k

2. A. A good splice is mechanically secure.

B. A good splice is electrically sound.

3. A. A bad splice is mechanically insecure and will part under pressure.

B. A splice that is poor electrically has resistance and may make intermittent connection.

4. A. F
B. T
C. F
D. T
E. T

- F. F
G. F
H. F
I. T
J. F

Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

DC OHM'S LAW

UNIT E3

Ed-Lab 651

INSTRUCTIONS ANSWER MANUAL

CC OWNS LAB

UNIT 65

UNIT E3 - DC OHM'S LAW

INSTRUCTOR'S ANSWER MANUAL

INFORMATION SHEET 5 - OHM'S LAW

ASSIGNMENT:

1. b. one volt applied to one ohm will cause a flow of one ampere.

2. a. $E=RI$; $I=E/R$; $R=E/I$.

3. c. increase.

4. b. decrease.

5. c. $E = 14 \text{ V}$ $R = 5 \text{ Ohms}$

$$I = \frac{E}{R} = \frac{14}{5} = \underline{2.8 \text{ A}}$$

6. b. $R = 30 \text{ Ohms}$ $I = 0.55 \text{ A}$

$$E = IR = (0.55)(30) = \underline{16.5 \text{ V}}$$

7. d. $E = 100 \text{ V}$ $I = 0.05 \text{ A}$

$$R = \frac{E}{I} = \frac{100}{0.05} = \underline{2000 \Omega}$$

$$8. \text{ c. } 6 \Omega \quad R = \frac{E}{I} = \frac{150}{25} = \underline{6 \Omega}$$

9. b. current flow will decrease.

10. c. either of the above. Either increases the voltage or decreases the resistance.

INFORMATION SHEET 6 - SCIENTIFIC NOTATION AND POWERS OF TEN

ASSIGNMENT:

1. a. 7000 7×10^3
 b. 550,000 5.5×10^5
 c. 7,480,000 7.48×10^6
 d. 47,658 4.77×10^4
 e. 897 8.97×10^2
 f. 0.00345 3.45×10^{-3}
 g. 0.39721 3.97×10^{-1}
 h. 0.0005 5×10^{-4}
 i. 0.00001579 1.58×10^{-5}
 j. 0.000500059 5×10^{-4}

2. a. 0.0000753 75.3×10^{-6}
 b. 798,000 0.798×10^6 or 798×10^3
 c. 57,365 57.4×10^3
 d. 5,000,000,000 5×10^9
 e. 0.000 000 009 5 9.5×10^{-9}
 f. 4,575,850 4.6×10^6
 g. 0.000 000 54 5.4×10^{-5}
 h. 14×10^7 140×10^6 or 0.14×10^9
 i. 957×10^{-13} 95.7×10^{-12}
 j. 0.257×10^4 2.57×10^3

3. a. $950 \times 0.001 = 9.5 \times 10^2 \times 10^{-3} = \underline{9.5 \times 10^{-1}}$
 b. $(0.000\ 0065) (60 \times 10^5) = 6.5 \times 10^{-6} \times 6 \times 10^6 = \underline{3.9 \times 10^1}$
 c. $(0.000\ 015) (19) (53 \times 10^{12}) = 1.5 \times 10^{-5} \times 1.9 \times 10^1 \times 5.3 \times 10^{13} = \underline{1 \times 10^{15}}$
 d. $(47.5) (585 \times 10^6) (0.0033) = 4.75 \times 10^1 \times 5.85 \times 10^8 \times 3.3 \times 10^{-3} = 4.75 \times 5.85 \times 3.3 \times 10^1 \times 10^8 \times 10^{-3} = \underline{9.17 \times 10^7}$
 e. $(295.4) (0.057 \times 10^3) (0.00144) = 2.95 \times 10^2 \times 5.7 \times 10^1 \times 14.4 \times 10^{-4} = 2.95 \times 5.7 \times 14.4 \times 10^2 \times 10^1 \times 10^{-4} = 242 \times 10^{-1} = \underline{2.42 \times 10^1}$

4. a. $2.7 \times 10^4 \div 2.4 \times 10^3$

$$\frac{2.7 \times 10^4}{2.4 \times 10^3} = \frac{2.7 \times 10^4 \times 10^{-3}}{2.4} = \underline{1.12 \times 10^1}$$

b. $820,000 \div 1.2 \times 10^2$

$$\frac{8.2 \times 10^4}{1.2 \times 10^2} = \frac{8.2 \times 10^4 \times 10^{-2}}{1.2} = \underline{6.83 \times 10^2}$$

c. $27,500 \div 1.7 \times 10^{-3}$

$$\frac{2.75 \times 10^4}{1.7 \times 10^{-3}} = \frac{2.75 \times 10^4 \times 10^3}{1.7} = \underline{1.62 \times 10^7}$$

d. $55 \times 10^{-3} \div 12 \times 10^{-6}$

$$\frac{5.5 \times 10^{-2}}{1.2 \times 10^{-5}} = \frac{5.5 \times 10^{-2} \times 10^5}{1.2} = \underline{4.58 \times 10^3}$$

e. $227,585 \div 5720$

$$\frac{2.8 \times 10^5}{5.72 \times 10^3} = \frac{2.28 \times 10^5 \times 10^{-3}}{5.72} = 0.399 \times 10^2 = \underline{3.99 \times 10^1}$$

5. a. $557,000 + 14,395$

$$557 \times 10^3 + 14.4 \times 10^3$$

$$\begin{array}{r} 557 \times 10^3 \\ + 14.4 \times 10^3 \\ \hline 571.4 \times 10^3 \end{array}$$

b. $6.92 \times 10^5 + 475 \times 10^3$

$$629 \times 10^3 + 475 \times 10^3$$

$$\begin{array}{r} 629 \times 10^3 \\ + 475 \times 10^3 \\ \hline 1104 \times 10^3 \end{array}$$

c. $758 \times 10^4 - 356 \times 10^2$

$$758 \times 10^4 - 3.56 \times 10^4$$

$$\begin{array}{r} 758.00 \times 10^4 \\ - 3.56 \times 10^4 \\ \hline 754.44 \times 10^4 \end{array}$$

d. $195 \times 10^{12} - 1.47 \times 10^{11}$

$$195 \times 10^{12} - 0.147 \times 10^{12}$$

$$\begin{array}{r} 195.000 \times 10^{12} \\ - 0.147 \times 10^{12} \\ \hline 194.853 \times 10^{12} \end{array}$$

e. $375 \times 10^3 + 450 \times 10^5$

$$3.75 \times 10^5 + 450 \times 10^5$$

$$\begin{array}{r} + 3.75 \times 10^5 \\ - 450.00 \times 10^5 \\ \hline 453.75 \times 10^5 \end{array}$$

6. a. $(53 \times 10^4)^2$

$$(53)^2 (10^4)^2 = 2809 \times 10^8 = \underline{2.81 \times 10^{11}}$$

b. $(10^7)^2 = 10^{14}$

c. $\sqrt{625 \times 10^4} = \sqrt{625} \times \sqrt{10^4} = 25 \times 10^2 = \underline{2.5 \times 10^3}$

d. $\sqrt{1960 \times 10^7} = \sqrt{196 \times 10^8} = \sqrt{196} \times \sqrt{10^8} = 14 \times 10^4 = \underline{1.4 \times 10^5}$

e. $\sqrt{484 \times 10^{-6}} = \sqrt{484} \times \sqrt{10^{-6}} = 22 \times 10^{-3} = \underline{2.2 \times 10^{-2}}$

7. a. $\frac{1}{200} = \frac{1}{0.2 \times 10^3} = \underline{5 \times 10^{-3}}$

b. $\frac{1}{0.004} = \frac{1}{0.4 \times 10^{-2}} = \underline{2.5 \times 10^2}$

c. $\frac{1}{0.00735} = \frac{1}{0.735 \times 10^{-2}} = \underline{1.36 \times 10^2}$

d. $\frac{1}{7000} = \frac{1}{.7 \times 10^4} = \underline{1.43 \times 10^{-4}}$

8. a. $\frac{(47000)^2 (0.00057)}{\sqrt{49 \times 10^4}} = \frac{(4.7 \times 10^4)^2 (5.7 \times 10^{-4})}{\sqrt{49 \times 10^4}} =$

$$\frac{(22.1 \times 10^8)(5.7 \times 10^{-4})}{7 \times 10^2} = \frac{22.1 \times 5.7 \times 10^8 \times 10^{-4} \times 10^{-2}}{7} =$$

$$\frac{125.97 \times 10^2}{7} = 18 \times 10^2 = \underline{1.8 \times 10^3}$$

b. $\frac{1}{(7.59) \sqrt{50 \times 10^4 \times 20 \times 10^{-12}}} = \frac{1}{(7.59) \sqrt{100 \times 10^{-8}}} =$

$$\frac{1}{(7.59)(10) \times 10^{-4}} = \frac{1}{759 \times 10^{-4}} = \frac{1}{0.759 \times 10^{-1}} =$$

$$1.32 \times 10^1 = 0.0132 \times 10^3 = \underline{13.2}$$

EXPERIMENT NO. 12 - SOLVING OHM'S LAW FOR VOLTAGE

QUESTIONS:

4. Calculate the +V1 voltage as shown below. Use $I = 0.003 \text{ A}$.

STEP 1 :	$E_{V1} = IR$
STEP 2 :	$E_{V1} = (.003)(2200)$
STEP 3 :	$E_{V1 \text{ CALCULATED}} = \underline{6.6 \text{ V}}$

7. Measure the +V1 output voltage and record the value below.

$E_{V1 \text{ MEASURED}}$	$= \underline{6.5} \text{ V}$
---------------------------	-------------------------------

8. Compare the calculated voltage from Step 4 to the measured voltage from Step 7. Account for the difference, if any. The difference is due to meter accuracy and component tolerances.

11. Enter the current in the formula below and calculate the voltage at +V3. Use I in mA because R is in K.

$E_{V3} = IR$	$E_{V1} = (4.95)(1)$
$E_{V3 \text{ CALCULATED}}$	$= \underline{4.95} \text{ V}$

12. Remove the circuit wiring.

Rewire the meter to the 0-10 V range, measure +V3 and record it below.

$E_{V3 \text{ MEASURED}}$	$= \underline{4.95} \text{ V}$
---------------------------	--------------------------------

13. Compare the calculated and measured voltages. Account for the difference if any. The difference is due to meter accuracy and component tolerance.

ASSIGNMENT:

1. b. $E = I \cdot R$
2. a. $E = I \cdot R$
 $E = (0.02) (2700)$
 $E = \underline{54 \text{ V}}$
3. d. $E = I \cdot R$
 $E = (3) (50)$
 $E = \underline{150 \text{ V}}$
4. c. $E = I \cdot R$
 $E = (0.075) (550)$
 $E = \underline{41.25 \text{ V}}$
5. d. current through the resistor increases.

EXPERIMENT NO. 13 - SOLVING OHM'S LAW FOR CURRENT

QUESTIONS:

1. Connect the voltmeter to the +V2 supply as shown in Figure 5.

Measure and record the voltage.

$$+V2 \text{ MEAS.} = \underline{9.0} \text{ V}$$

3. Calculate the current that will flow in the circuit of Figure 5 when the power is applied.

Follow the steps shown below. Use R in K and the answer is in mA.

$$\text{STEP 1: } I = \frac{E}{R}$$

STEP 2: Enter the voltage read in Step 1 and the resistance value shown in Figure 6.

$$I = \frac{(0.9)}{(2.2)}$$

STEP 3: Perform the calculation.

$$I \text{ CALC.} = \underline{4.09} \text{ mA}$$

5. Read the current flow in the circuit from the meter and record it below.

$$I \text{ MEASURED} = \underline{4.1 \text{ ma}}$$

6. Compare the actual and calculated currents. Are they close in value?

The actual current is 4.1 ma
the calculated value is 4.09, which is very
close.

7. Calculate the current that will flow in the circuit of Figure 7 when $R = 3.3 \text{ K}$.

$$I = \frac{E}{R}$$
$$I = \frac{9}{3.3}$$
$$I_{\text{CALC.}} = \underline{2.72 \text{ ma}}$$

9. Apply power, measure the current flow and record the value below.

$$I_{3.3 \text{ K MEAS.}} = \underline{2.7 \text{ ma}}$$

10. Compare the calculated current value (Step 7) to the measured value obtained in Step 9. Are they close? Yes

ASSIGNMENT:

1. a. $I = E/R$
2. d. all of the above.

$$I = \frac{E}{R} = \frac{20}{10000} = \underline{0.002 \text{ A} = 2 \text{ mA} = 2000 \mu\text{A}}$$

3. c.

$$I = \frac{E}{R} = \frac{25}{4700} = \underline{0.0053 \text{ A} = 5.3 \text{ mA}}$$

4. d. none of the above.

5. b. current will increase.

6. a. $I = \frac{E}{R} = \frac{50}{2000} = \underline{0.025 \text{ A} = 25 \text{ mA}}$

b. $E = IR = 0.003 \times 25000 = \underline{75 \text{ V}}$

c. $I = \frac{E}{R} = \frac{5}{10000} = \underline{0.0005 \text{ A} = 0.5 \text{ mA}}$

d. $I = \frac{E}{R} = \frac{75}{5000} = \underline{0.015 \text{ A} = 15 \text{ mA}}$

e. $E = IR = 0.02 \times 1200 = \underline{24 \text{ V}}$

EXPERIMENT NO. 14. - SOLVING OHM'S LAW FOR RESISTANCE

QUESTIONS:

1. Connect the voltmeter to the +V3 supply as shown in Figure 5, measure the voltage and record the value.

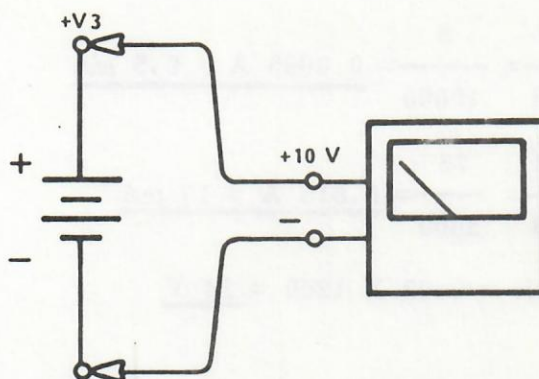


Figure 5 - Measuring the voltage at +V3; EXPERIMENT.

$$V_3 = \underline{5.0} \text{ V}$$

5. Based on your adjustment and measured current and voltage, calculate the circuit resistance of Figure 6 by following the steps listed below.

STEP 1: Write the formula to solve for R.

$$R = \frac{E}{I}$$

STEP 2: Enter the known quantities.

$$R = \frac{(5.0)}{(5.0)}$$

STEP 3: Perform the calculation.

$$R_{\text{CALC.}} = \underline{1 \text{ K}}$$

7. Use an external ohmmeter and measure the pot resistance between the arm (yellow) and the black jack; record the value below.

$$R_{\text{POT MEAS.}} = \underline{987 \Omega}$$

8. Compare the actual and calculated resistances. Are they close in value? Yes

10. Calculate the circuit resistance as outlined below. Use I in mA.

STEP 1:	$R = \frac{E}{I}$
STEP 2:	$R = \frac{(5.0)}{(5.5)}$
STEP 3:	$R_{\text{CALC.}} = \underline{0.91} \text{ K}$

12. Use an external ohmmeter and measure the pot resistance with the ohmmeter and record the value below.

$R_{\text{POT MEAS.}} = \underline{903 \Omega}$

Compare the calculated and measured resistance values. Are they close? Yes

ASSINGMENT:

- c. $R = \frac{E}{I}$
- b. $R = \frac{E}{I} = \frac{30}{0.01} = \underline{3000 \Omega} = \underline{3 \text{ K}}$
- a. $R = \frac{E}{I} = \frac{75}{0.015} = \underline{5000 \Omega} = \underline{5 \text{ K}}$
- c. $E = IR = (0.01)(1500) = \underline{15 \text{ V}}$

5. a. $E = IR = (0.00017)(5000) = \underline{0.85 \text{ V}}$

b. $I = \frac{E}{R} = \frac{100}{20,000} = \underline{0.005 \text{ A} = 5 \text{ mA}}$

c. $R = \frac{E}{I} = \frac{75}{0.02} = \underline{3750 \Omega = 3.75 \text{ K}}$

d. $R = \frac{E}{I} = \frac{5}{0.002} = \underline{2500 \Omega = 2.5 \text{ K}}$

e. $R = \frac{E}{I} = \frac{18}{0.03} = \underline{600 \Omega = 0.6 \text{ K}}$

EXPERIMENT NO. 15 - GRAPHING VOLTAGE - CURRENT CHARACTERISTICS

QUESTIONS:

4. Advance the +V1 control slowly until the meter reads 5 V.

Observe and read the current flow on the panel meter and record the value in Table 1.

VOLTS	I (mA)
5	5.0
10	10.0
15	15.0
18	18.0

7. Plot the data developed in Table 1 on the graph of Figure 7 on the next page and connect the plot points to form a continuous line.

Is the plot linear? Yes

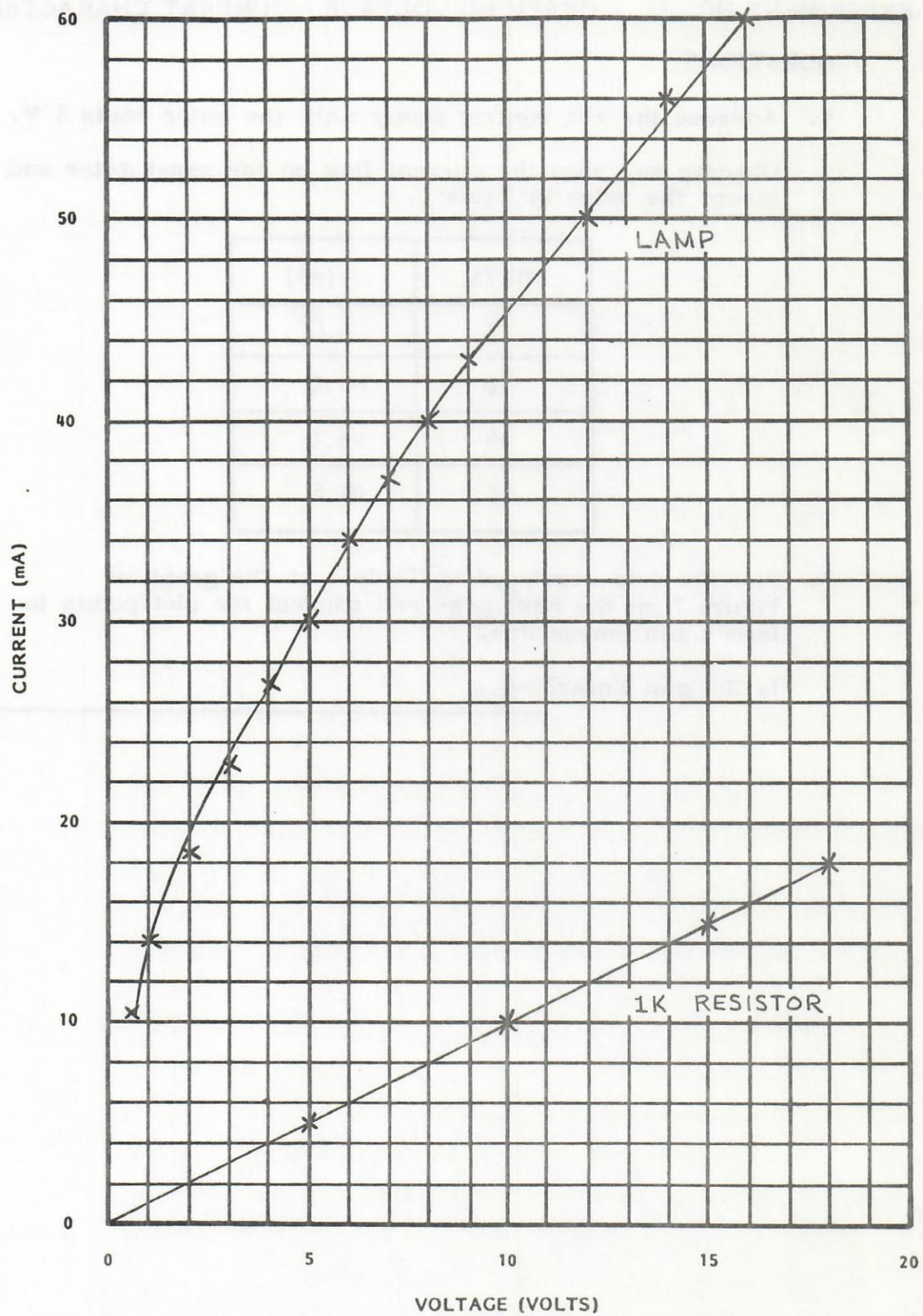


Figure 7 - Plot of a Volt-Ampere characteristics for the 1K resistor and the Incandescent Lamp.

8. Shut-off the Ed-Lab Trainer power.

Use the external meter (ohmmeter setting) to measure the cold resistance of the lamp, LOAD 1, and record the value below.

$$R_{\text{LAMP 1 (COLD)}} = 26 \Omega$$

11.

VOLTS	I (mA)	VOLTS	I (mA)
0.5	11.5	8	40
1	14.0	* 9	43
2	18.5	**10	46
3	23.0	12	50
4	27.0	14	56
5	30.0	16	60
6	34.0	+ 18	65
7	37.0		

- * Use the -V2 supply to increase voltage above 9 V.
 ** Turn off power and change from the 50 mA to the 100 mA shunt.
 + May go off-scale on the graph.

TABLE 2 - Volt-Ampere characteristics of the incandescent lamp No. 1.

12. Plot the data developed in Table 2 on the graph in Figure 7; connect the plot points to form a continuous line.

Is the plot linear or non-linear? The plot is non-linear.

13. Calculate the resistance of the lamp when 10 Volts is applied to it. (Measure I from the graph.)

$$R = \frac{E}{I} = \frac{10}{(46)} = 217.4 \Omega$$

14. Compare the hot resistance at 10 Volts to the cold resistance measured in step 9. What does it show? The lamp resistance increases with temperature (applied voltage).

ASSIGNMENT:

1. d. all of the above.
2. b. current.
3. a. linear.
4. a. voltage.
5. b. straight line plot when graphed.
6. c. 42 ohms.

$$\#40 \quad E = 6.3 \text{ V} \quad I = 150 \text{ mA.}$$

$$R = \frac{E}{I} = \frac{6.3}{0.15} = \underline{42 \Omega}$$

7. a. 30 ohms.

$$R = \frac{E}{I} = \frac{3}{0.1} = \underline{30 \Omega}$$

8. c. 112 mA.

EXPERIMENT NO. 16 - RESISTOR COLOR CODE

QUESTIONS:

3. Examine the list to see if each resistor is approximately the stated value. Is this so? Yes

NO.	VALUE	COLOR CODE BANDS				MEASURED VALUE
		A	B	C	D	
1	100	BRN	BLK	BRN	GLD	101 Ω
2	100	BRN	BLK	BRN	GLD	102 Ω
3	1 K	BRN	BLK	RED	GLD	996 Ω
4	1 K	BRN	BLK	RED	GLD	999 Ω
5	2.2 K	RED	RED	RED	GLD	2.18 K
6	3.3 K	ORNG	ORNG	RED	GLD	3.32 K
7	4.7 K	YELL	VIOL	RED	GLD	4.69 K
8	10 K	BRN	BLK	ORNG	GLD	10.17 K
9	15 K	BRN	GRN	ORNG	GLD	15.17 K
10	22 K	RED	RED	ORNG	GLD	22.3 K
11	33 K	ORNG	ORNG	ORNG	GLD	32.8 K
12	56 K	GRN	BLUE	ORNG	GLD	56.9 K
13	100 K	BRN	BLK	YELL	GLD	101.0 K
14	470 K	YELL	VIOL	YELL	GLD	467 K
15	1 M	BRN	BLK	GRN	GLD	1.009 M
16	4.7 M	YELL	VIOL	GRN	GLD	4.77 M

TABLE 4 - Trainer panel resistance values.

NO.	COLOR CODE				RESISTOR VALUE	TOLERANCE	MEASURED VALUE
	A	B	C	D			
1.	BRN	GRN	BRN	SILV	150 Ω	10 %	161 Ω
2.	RED	VIOL	BRN	GLD	270 Ω	5 %	280 Ω
3.	ORNG	ORNG	BRN	GLD	330 Ω	5 %	339 Ω
4.	RED	RED	BRN	NONE	220 Ω	20 %	202 Ω
5.	YELL	VIOL	BLK	NONE	47 Ω	20 %	40 Ω
6.	GRN	BLUE	ORNG	GLD	56 K	5 %	55.1 K
7.	ORNG	WHITE	ORNG	SILV	39 K	10 %	47 K
8.	GREY	RED	RED	SILV	8.2 K	10 %	8.6 K
9.	RED	RED	YELL	SILV	220 K	10 %	209 K
10.	YELL	VIOL	YELL	GLD	470 K	5 %	463 K

TABLE 5 - Resistor card measurements.

7. Obtain an ohmmeter and measure each resistor. Enter the value in the MEASURED VALUE column.

Are the measured and coded values all within tolerance? Yes

10.

NO.	RESISTOR TYPE	DRAWING	MARKED VALUE	MEASURED VALUE
1.	CARBON FILM		3.3 K $\pm$ 5%	3.25 K
2.	COMPOSITION		15 Ω $\pm$ 5%	14.5 Ω
3.	WIREWOUND		1.5 K $\pm$ 5%	1.55 K
4.	WIREWOUND		100 Ω $\pm$ 10%	100 Ω

TABLE 6 - Resistor type identification.

12. Measure the resistance value of each resistor and enter it in the last column.

Are the resistance readings within tolerance? Measured
values and tolerances will vary with resistances
used.

ASSIGNMENT:

- | | | | | |
|----|---------------|--------|----------------------|--------|
| 1. | a. Violet | 7 | f. Brown | 1 |
| | b. Red | 2 | g. White | 9 |
| | c. Grey | 8 | h. Green | 5 |
| | d. Black | 0 | i. Blue | 6 |
| | e. Orange | 3 | j. Yellow | 4 |
| 2. | a. Violet | 7 | f. Yellow | 4 |
| | b. Red | 2 | g. White | 9 |
| | c. Grey | 8 | h. Blue | 6 |
| | d. Black | 0 | i. Green | 5 |
| | e. Orange | 3 | j. Brown | 1 |
| 3. | a. 0.001 % | Yellow | c. 0.01 % | Orange |
| | b. 1.0 % | Brown | d. 0.1 % | Red |
| 4. | a. Silver | 10% | c. Gold | 5% |
| | b. No Color | 20% | | |
| 5. | a. 47 K, 5% | | c. 2.2 Ω , 5% | |
| | b. 5.6 M, 20% | | d. 180 K, 5%, 1% | |

6. T. $47000 \ 5\% = 47000 \times 0.05 = 2350$

$$47000 + 2350 = 49,350$$

7. T. $5,600,000 - 20\% =$
 $5,600,000 \times 0.2 = 1,120,000$
 $5,600,000 - 1,120,000 = 4,480,000$

8. F. Decimal multipliers Gold and Silver permit values below 10 ohms.

9. T.

10. T.

11. F. A value of 1800 ohms is available only in 5 or 10% tolerances as shown in Table 3.

12. T.

EXPERIMENT NO. 17 - SERIES RESISTORS

QUESTIONS:

1.

+V2 = 9.0 VOLTS

3. Read the series current flow on the 0-5 scale and enter the result below.

I_{SERIES} = 1.6 mA

4. Convert the current reading to Amperes (by moving the decimal point 3 places to the left). For example 3.5 mA equals 0.0035 A.

Enter the result of the conversion below.

I_{SERIES} = 0.0016 Amps

Substitute the measured value of +V2 from step 1 and the measured value of I_S, in Amperes, from step 4, in the box below.

$R_T = \frac{(9.0) \text{ VOLTS}}{(0.0016) \text{ AMPS}}$

6. Use a calculator to determine the value of R_T from the above data.

The value of R_T, based on the measurements, is:

MEASURING
E AND I

R_T = 5625 OHMS

7. The expected theoretical value of R_T is given by the sum of the two resistances.

$$R_T = R_1 + R_2 \\ = (3.3K) + (2.2K)$$

THEORETICAL	$R_T = \underline{5.5 K} \text{ OHMS}$
-------------	--

How does the measured value of R_T in step 6 compare with the theoretical value of R_T above? The measured value compares well with the theoretical value considering the tolerance.

Does the laboratory experiment result agree with the theoretical result? Yes, it is within the specified tolerance.

9. Apply power and read the new current, I_N , and enter the result below.

$I_N = \underline{1.1} \text{ mA}$

10. Convert the new series current from mA to amperes.

$I_N = \underline{0.0011} \text{ AMPS}$

11. Calculate the new total resistance (R_T) based on the measurement of current in Step 10, using Ohm's Law.

$$R_T = \frac{+V_2}{I_N} \\ R_T = \frac{(9.0) \text{ VOLTS}}{(0.0011) \text{ AMPS}}$$

The value of R_T based on measurements, is:

FROM CURRENT MEASUREMENTS FOR 4.7 AND 3.3 K	$R_T = \underline{8.18 \text{ K}} \text{ OHMS}$
---	---

12. Calculate the new theoretical expected value for an equivalent single resistor.

$$R_T = R_1 + R_2$$

$$R_T = (4.7\text{K}) + (3.3\text{K})$$

THEORETICAL FOR 4.7 K AND 3.3 K	$R_T = \underline{8.0 \text{ K}} \text{ OHMS}$
---------------------------------	--

13. How does the value determined from the measurements in step 11 compare to the theoretical value computed in step 12?

The measured value agrees with the theoretical value taking into account the tolerance.

15. Measure the current in miliamperes, convert it to Amperes and enter the results below.

$I_S = \underline{0.8} \text{ mA}$	$I_S = \underline{0.0008} \text{ AMPS}$
------------------------------------	---

16. Based on the current measurement, calculate the total resistance, R_T , from the current (step 15) and the voltage (step 2).

$$R_T = \frac{+V_2}{I_S} = \frac{(9.0) \text{ VOLTS}}{(0.0008) \text{ AMPS}}$$

BASED ON CURRENT FOR FOUR RESISTORS	$R_T = \underline{11.25 \text{ K}} \text{ OHMS}$
-------------------------------------	--

17. Calculate the theoretical total resistance, R_T , by adding the values of each resistor.

$$R_T = (1.0K) + (2.2K) + (3.3K) + (4.7K)$$

THEORETICAL FOR FOUR RESISTORS	$R_T = \underline{11.2 K} \text{ OHMS}$
--------------------------------------	---

18. How do the resistances in steps 16 and 17 compare? It is
within the specified tolerance range.

How would you explain any differences between the two answers? The theoretical value assumes ideal resistors with 0% tolerance. The measured values take into account the tolerance of the resistor.

21. Record the R_T below, as measured by the ohmmeter

OHMMETER FOR FOUR RESISTANCES	$R_T = \underline{11.28 K} \text{ OHMS}$
-------------------------------------	--

How does the value above, as measured with the ohmmeter, compare with the results obtained in steps 16 using current measurement and step 17 using the theoretical calculation? The small difference is due to the accuracy of the measuring instrument and component tolerances.

ASSIGNMENT:

1. a. one current path.

2. a. 8.85 mA

$$\begin{aligned} R_T &= R_1 + R_2 + R_3 \\ &= 1 \text{ K} + 4.7 \text{ K} + 5.6 \text{ K} \\ &= 11.3 \text{ K} \end{aligned}$$

$$I = \frac{E}{R} = \frac{100}{11,300} = \underline{0.00885 \text{ A} = 8.85 \text{ mA.}}$$

3. c. 1 K

$$R_T = \frac{E}{I} = \frac{30}{0.01} = 3 \text{ K}$$

$$\frac{3\text{K}}{3} = \underline{1 \text{ K}}$$

$$\begin{aligned} 4. \quad R_T &= (150) - (20+20+20) \\ &= 150 - 60 = \underline{90\Omega} \end{aligned}$$

5. T

6. F The current is the same at any point in the circuit.

$$7. \quad F \quad R_T = 1 \text{ K} + 3.3 \text{ K} + 4.7 \text{ K} = 9 \text{ K}$$

8. (a)

$$\begin{aligned} R_T &= R_1 + R_2 + R_3 \\ &= 5 \text{ K} + 1.2 \text{ K} + 47 \text{ K} \\ &= \underline{53.2 \text{ K}} \end{aligned}$$

- (b)

$$\begin{aligned} R_T &= R_1 + R_2 + R_3 \\ &= 1\text{K} + 3.3 \text{ K} + 100 \text{ K} \\ &= \underline{104.3 \text{ K}} \end{aligned}$$

- (c)

$$P_T = \frac{E}{I} = \frac{10}{0.05} = 200$$

$$\begin{aligned} R_3 &= R_T - (R_1 + R_2) \\ &= 200 - (125) \\ &= \underline{75\Omega} \end{aligned}$$

INFORMATION SHEET 7 - ELECTRICAL ENERGY AND POWER

ASSINGMENT:

1. F The energy stored is equal to the charge in coulombs multiplied by the voltage, $\omega = EQ$.
2. T
3. T
4. T $I = Q/t = 6/3 = 2 \text{ A}$
5. T
6. F $P = E \cdot I$ or E^2/R
7. T
8. F $P = E^2/R$
9. F ω represents Energy stored.
10. F The 12 volt battery can deliver 12 W as opposed to 6.75 W for the 45 volt battery.
11. T
12. F A coulomb is equal to 6.25×10^{18} electrons or 6.25 Trillion TRILLION.
13. F One Watt is equal to 1 Joule per second.
14.
 - a. $P = E \cdot I$
 $= (12)(0.75) = \underline{9 \text{ W}}$
 - b. $P = I^2R$
 $= (3.5)^2(10) = \underline{122.5 \text{ W}}$
 - c. $P = E^2/R$
 $= (40)^2 / (200) = \underline{8 \text{ W}}$
 - d. $P = E \cdot I$
 $(9)(0.375) = \underline{3.4 \text{ W}}$

15.

$$\begin{aligned} \text{KWh} &= \frac{W \cdot t}{1000} \\ &= \frac{(1,000)(30)(7)}{(60)(1000)} \\ &= \frac{210,000}{60,000} \\ &= \underline{3.5 \text{ KWh}} \end{aligned}$$

EXPERIMENT NO. 18 - POWER DISSIPATION

QUESTIONS:

12. Carefully grasp the 1/4 watt resistor between the thumb and forefinger of your left hand and the 1/2 watt resistor the same way with the right hand and observe which is hotter. Then release the resistors.

Which resistor gets hotter? The 1/4 watt resistor is hotter.

Why? The same amount of power is being dissipated in both of the resistors, but the 1/4 watt resistor becomes hotter because it is smaller in size.

13. Calculate the power being dissipated by both resistors. Note that E is 7 volts and R is 100 ohms.

$$P = \frac{E^2}{R}$$

$$P = \frac{(7)^2}{(100)}$$

$P = \underline{0.49} \text{ W}$

Which resistor, if any, is being operated higher than its ratings? The 1/4 watt resistor is being operated higher than its rating.

16. Turn on the power and read the circuit current flow. Record the current below.

$I = \underline{1.6} \text{ mA}$

17. Compute the total power furnished by the source. (Recall that +V2 is 9 Volts.)

$$P_S = E \cdot I \text{ (E in Volts, I in mA, P in mW)}$$

$$P_S = (9)(1.6)$$

SOURCE POWER	$P_S = \underline{14.4} \text{ mW}$
-----------------	-------------------------------------

18. Calculate the power dissipated by each resistor from:

$$P_1 = I^2 \cdot R_1 \text{ (I in mA, R in K, P in mW)}$$

$$P_1 = (1.6)^2 \cdot 2.2$$

For 2.2 K	$P_1 = \underline{5.632} \text{ mW}$
-----------	--------------------------------------

$$P_2 = I^2 \cdot R_2$$

$$P_2 = (1.6)^2 \cdot 3.3$$

For 3.3 K	$P_2 = \underline{8.448} \text{ mW}$
-----------	--------------------------------------

19. Add the powers dissipated by each resistor to obtain the total power, P_T , dissipated.

$$P_T = P_1 + P_2$$

$$P_T = (5.63) + (8.44)$$

TOTAL POWER IN RESISTORS	$P_T = \underline{14.08} \text{ mW}$
-----------------------------	--------------------------------------

Does the total power dissipated (P_T) above equal the power supplied by the source, P_s , as calculated in Step 17?

Yes, there is a small difference owing to the accuracy of the measurement in step 16.

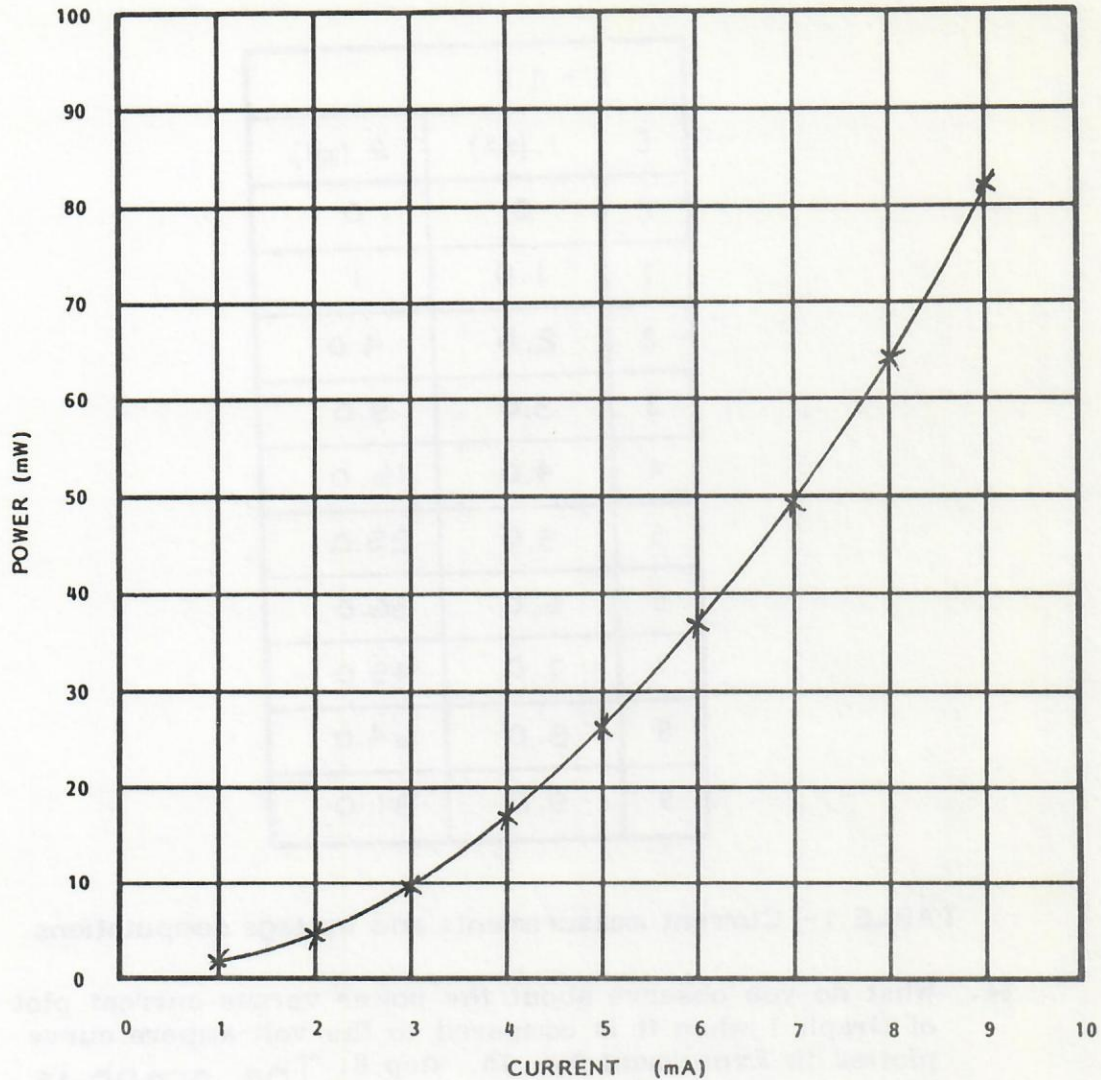
22. Using a calculator, determine the wattage dissipation of the 1K resistor for each voltage setting, from 1 to 9 volts, and enter them in Table 1. Use the formula

$$P = E \cdot I \text{ (where E is in volts, I in mA, P in mW)}$$

R = 1 K		
E	I (mA)	P (mW)
0	0	0
1	1.0	1
2	2.0	4.0
3	3.0	9.0
4	4.0	16.0
5	5.0	25.0
6	6.0	36.0
7	7.0	49.0
8	8.0	64.0
9	9.0	81.0

TABLE 1 - Current measurements and wattage computations.

24. What do you observe about the power versus current plot of Graph 1 when it is compared to the volt-ampere curve plotted in Experiment No. 15, step 8. The graph is non-linear as with the plot of the current through an incandescent lamp.



GRAPH 1 - Plot of power versus current flow.

26. Determine the resistance and tolerance rating and wattage rating (based on physical size) and resistor type for each resistor. Enter your observations in Table 2.

#	RESISTANCE	TOLERANCE	TYPE	WATTAGE
1	6.8 Ω	5%	COMP	1 W
2	5.1 K	5%	COMP	1/4 W
3	10 K	10%	COMP	1/2 W
4	150 Ω	10%	WW	10 W

TABLE 2 - Resistor characteristics.

ASSIGNMENT:

1. d. both the microwatt and the milliwatt.
2. d. all of the above.
3. c. $I \cdot E$
4. a. 3 milliwatts

$$0.003 \text{ W} \times 10^{-3} = \underline{3 \text{ mW}}$$

5. b. 450 mW

$$\begin{aligned} W &= E I \\ &= 30 \times 15 \\ &= \underline{450 \text{ mW}} \end{aligned}$$

6. a. 0.03 W

$$\begin{aligned} W &= E^2/R \\ &= 30^2/30 \text{ K} \\ &= \underline{0.03 \text{ W}} \end{aligned}$$

7. b. Increases. Example:

$$\begin{array}{llll} E = 10 & R = 10 & I = 1 \text{ A} & W = \underline{10 \text{ W}} \\ E = 10 & R = 5 & I = 2 \text{ A} & W = \underline{20 \text{ W}} \end{array}$$

8. c. 4.

$W = I^2 R$ When I is doubled and then squared the increase is by four.

9. c. 2 W.

$$\begin{aligned} W &= I^2 R \\ &= (0.02)^2 5 \text{ K} \\ &= \underline{2 \text{ W}} \end{aligned}$$

10. d. 11 W

$$\begin{aligned} W_{R3} &= W_T - (W_{R1} + W_{R2}) \\ &= 30 - (8 + 11) \\ &= \underline{11 \text{ W}} \end{aligned}$$

11. T.

12. F. The power will increase by four times.

13. T. $W = E^2/R$ $E = \sqrt{WR} = \sqrt{100 \text{ K} \times 1} = \underline{316.23 \text{ V}}$

14. F. They will be equal to 2 K at 4 W.

15.

(a) $W = IE = 0.025 \times 35 = \underline{0.875 \text{ W}}$

(b) $W = I^2 R = (0.03)^2 (5000) = \underline{4.5 \text{ W}}$

(c) $W = I^2 R_{1+R2} = (0.015)^2 (5 \text{ K} + 5 \text{ K}) = \underline{2.25 \text{ W}}$

(d) $W = E^2 / R = (20)^2 / (20,000) = \underline{0.02 \text{ W}}$

Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

DC CIRCUITS & LAWS

UNIT E4

Ed-Lab 851

INSTRUCTOR'S ANSWER MANUAL

DC CIRCUITS & LAWS

UNIT 24

UNIT E4 - DC CIRCUITS & LAWSINSTRUCTOR'S ANSWER MANUAL

EXPERIMENT NO. 19 - APPLICATION OF OHM'S LAW

QUESTIONS:

2. Enter the data in the last column of Table 1.

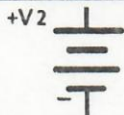
CIRCUIT COMPONENT	CIRCUIT SYMBOL	VOLTAGE LETTER	VOLTAGE READING
VOLTAGE SOURCE		E_S	<u>9.0 v</u>
LAMP		E_L	<u>4.8 v</u>
RESISTOR		E_R	<u>2.7 v</u>
COIL		E_C	<u>1.3 v</u>
SPEAKER		E_{SP}	<u>0.2 v</u>

TABLE 1 - Voltage data for the circuit of Figure 2.

3. Since the value of the resistor is known, 100 ohms, and the voltage drop across it is also known (Table 1), the current flow can be determined using Ohm's Law.

$$I_S = \frac{E_R}{R}$$

$$= \frac{(2.7)}{100}$$

Remember, dividing by 100 is done by moving the decimal point in the numerator two places to the left. Write your answer in the box below.

CIRCUIT CURRENT BASED ON VOLTAGE MEASUREMENTS	$I_S = \underline{0.027} \text{ Amps}$
---	--

$$4. \quad R_L = \frac{E_L}{I_S} = \frac{4.8}{0.027} = \underline{177.78 \Omega}$$

$$R_C = \frac{E_C}{I_S} = \frac{1.3}{0.027} = \underline{48.19 \Omega}$$

$$R_{SP} = \frac{E_{SP}}{I_S} = \frac{0.2}{0.027} = \underline{7.41 \Omega}$$

COMPONENT	DESIGNATION	R CALCULATED
LAMP	R_L	<u>177.78 Ω</u>
COIL	R_C	<u>48.19 Ω</u>
SPEAKER	R_{SP}	<u>7.41 Ω</u>

TABLE 2

ASSIGNMENT:

1. d. it requires cutting a wire or printed circuit foil.
2. c. resistance and voltage across one of the series components.
3. d. all of the above.
4. c. 7.5 V

$$\begin{aligned} E &= I R \\ &= (0.5)(15) \\ &= \underline{7.5 \text{ V}} \end{aligned}$$

5.

$$R1 = \frac{E}{I} = \frac{5}{0.02} = \underline{250 \Omega}$$

$$E_{R2} = I R = (0.02)(500) = \underline{10 \text{ V}}$$

$$R4 = \frac{E}{I} = \frac{25}{0.02} = \underline{1,250 \Omega}$$

EXPERIMENT NO. 20 - KIRCHHOFF'S VOLTAGE LAW

QUESTIONS:

2. Enter the data in Table 1 and add the individual voltage drops to result in the sum.

V_1	<u>1.4</u>	V_1
V_2	<u>3.0</u>	V_2
V_3	<u>4.6</u>	V_3
SUM	<u>9.0</u>	V_T

TABLE 1 - Voltage drops and sums for the circuit of Figure 3.

3. Shift the voltmeter to the +10 volt range, measure the source voltage and enter it below.

$V_S = $ <u>9.0</u> V

4. Compare the total voltage from step 2, Table 1, to the measured source voltage, V_S , made in step 3.

How do the measured and calculated source voltage values compare? The measured value is the same as the calculated value.

6. Measure the voltages V_1 and V_4 in the inside loop No. 1 and enter them in Table 2. Then calculate and enter the sum in the Table.

LOOP NO. 1		
V_1	<u>2.6</u>	V
V_4	<u>6.4</u>	V
SUM	<u>9.0</u>	V

TABLE 2 - Loop No. 1 voltages.

7. Measure V_S and record it below.

$V_S = \underline{\quad 9.0 \quad} \text{ V}$

Compare V_S , above, to the sum from step 6. Are they the same value or close? They are the same value.

8. Measure the voltages around the outside loop 2 and enter the readings in Table 3 and total them.

LOOP NO. 2	
V_1	<u>2.6</u> V
V_2	<u>2.5</u> V
V_3	<u>3.9</u> V
SUM	<u>9.0</u> V

TABLE 3 - Loop No. 2 voltages.

9. The sum in Table 3 should equal the source voltage measured earlier in step 7. Are they equal or very close? They are equal.
10. Add the voltages algebraically using the proper signs as shown.

LOOP NO. 3	
V_2	<u>+ 2.5</u> V
V_3	<u>+ 3.9</u> V
V_4	<u>- 6.4</u> V
SUM	<u>0 V</u>

TABLE 4 - Loop No. 3 voltages. Voltage V_4 acts as the source voltage.

11. How does the algebraic sum compare to the expected zero volts? The algebraic sum is zero.

14. Measure V_1 and V_2 and enter them below in Table 5.

V_1	<u>0.9</u> V
V_2	<u>3.1</u> V
SUM	<u>4.0</u> V

TABLE 5 - Voltages for Figure 7.

15. Total V_1 and V_2 to determine the source voltage, V_S .
16. Measure and record the source voltage below.

$$V_S = \underline{4.1 \text{ V}}$$

How does V_S measured compare to the sum obtained in Table 5? The measured value is close to the calculated value.

18. Measure V_S and V_1 ; record them in Table 6. Do not measure V_2 in Figure 7 yet. Subtract V_1 from V_S to obtain the expected V_2 .

EXPECTED V_2	→	V_S	<u>9.0</u> V
		V_1	<u>- 2.0</u> V
		$V_S - V_1$	<u>7.0</u> V

TABLE 6 - Determining V_2 .

19. Measure V_2 with the voltmeter and record it below.

$$V_2 \text{ MEAS.} = \underline{7.0 \text{ V}}$$

20. Compare V_2 measured with the expected V_2 calculated in step 18. Are they close? The measured value is the same as the calculated value.

ASSIGNMENT:

1. F. The voltage drops are all additive and equal to the source voltage.
2. F. They are equal to zero volts.
3. T.
4. T.
5. T.

$$\begin{aligned}V_{R1} &= V_S - V_{R2} - V_3 \\&= 30 - 15 - 10 \\&= \underline{5 \text{ V}}\end{aligned}$$

6. (a)

$$\begin{aligned}V_5 &= V_3 - V_4 - V_6 \\&= 6 - 2 - 0.75 \\&= \underline{3.25 \text{ V}}\end{aligned}$$

(b)

$$\begin{aligned}V_2 &= V_S - V_1 - V_3 \\&= 30 - 12 - 6 \\&= \underline{12 \text{ V}}\end{aligned}$$

EXPERIMENT NO. 21 - VOLTAGE DIVIDERS

QUESTIONS:

2. Measure V_s and V_{out} using switch SA and record the voltages in Table 1.

V_s (SA UP)	9.0 V
V_{out} (SA DOWN)	6.2 V

TABLE 1 - Measured voltage values for the voltage divider in Figure 4.

3. Substitute the measured value of V_s from Table 1 above.

$$V_{out} = (9.0) \frac{2.2}{3.2}$$

Use a calculator to determine this expected output voltage and enter the value below.

$$V_{OUT\ EXPECTED} = 6.19\ V$$

4. How does the calculated expected value from step 3 above compare with the measured value from Table 1? The

measured value is very close to the expected value.

9. Measure the output voltage and enter it below.

$$V_o = 5.3\ V$$

Is the measured value of V_o close to the expected value of 5.4 V? Yes

11. Substitute the measured value of V_S from step 2, Table 1.

$$V_{OUT1} = (9.0) \frac{4.7}{6.7}$$

Use a calculator to determine the expected output voltage and enter the value below.

$$V_{out1, EXPECTED} = 6.31 \text{ V}$$

12. Measure V_{OUT1} across the 4.7 K resistor and enter the voltage reading below.

$$V_{out1 MEASURED} = 6.2 \text{ V}$$

How does the measured voltage compare to the expected voltage calculated in step 11? It is close to the

expected value.

13. Use a calculator to determine the expected output voltage and enter the value below.

$$V_{out2, EXPECTED} = 7.66 \text{ V}$$

14. Measure V_{OUT2} across the 4.7 K and 1 K resistors ($R_2 - R_3$) and record the voltage reading below.

$$V_{out2 MEASURED} = 7.6 \text{ V}$$

How does the measured voltage compare to the expected voltage calculated in step 13? It is very close to the
expected value.

16. Wire the circuit of Figure 7 and measure V_{out} . Record V_{out} below.

$$V_{out} = \underline{4.5} \text{ V}$$

Half of V_S is 4.5 volts. Is V_{out} one half of V_S as expected? Yes

ASSIGNMENT:

1. a. voltage divider.
2. c. 54.2 V

$$\begin{aligned} V_O &= (V_S) \frac{R_2}{(R_1 + R_2)} \\ &= (60) \frac{47}{(47 + 5)} \\ &= \underline{54.2 \text{ V}} \end{aligned}$$

3. b. 16.3 V

$$\begin{aligned} V_O &= (V_S) \frac{R_2}{(R_1 + R_2)} \\ &= (24) \frac{10}{(4.7 + 10)} \\ &= (24) (0.68) = \underline{16.3 \text{ V}} \end{aligned}$$

4. c. 18.4 V

$$\begin{aligned} E_3 &= (40) \frac{4.7}{(2.2 + 3.3 + 4.7)} \\ &= (40)(0.46) = \underline{18.4 \text{ V}} \end{aligned}$$

5. d. 31.4 V

$$\begin{aligned} E_2 &= (40) \frac{(4.7 + 3.3)}{(2.2 + 3.3 + 4.7)} \\ &= (40)(0.78) = \underline{31.2 \text{ V}} \end{aligned}$$

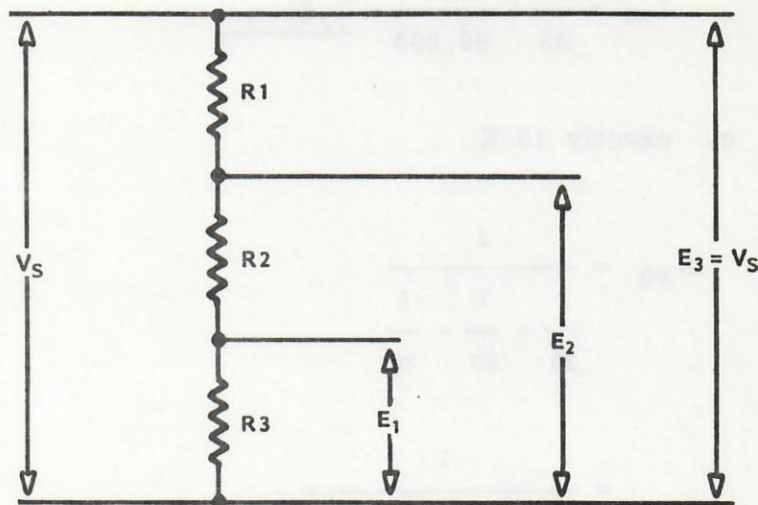
6. b. 8.8 V Using Kirchhoff's Voltage Law

$$\begin{aligned} E_{R1} &= V_S - (E_{R2} + E_{R3}) \\ &= 40 - (31.2) = \underline{8.8 \text{ V}} \end{aligned}$$

7. c. 12.8 V

$$\begin{aligned} E_{R2} &= V_S \frac{R_2}{(R_1 + R_2 + R_3)} \\ &= (40) \frac{3.3}{(2.2 + 3.3 + 4.7)} \\ &= (40)(0.32) = \underline{12.9 \text{ V}} \end{aligned}$$

8.



9.

$$\begin{aligned} R_1 &= \frac{R_2 (V_S - V_O)}{V_O} \\ &= \frac{4.7 (10 - 5)}{5} \\ &= \underline{4.7 \text{ K}} \end{aligned}$$

Recall that equal value resistors will divide V_S by R_N .

INFORMATION SHEET 9 - PARALLEL RESISTANCES

ASSIGNMENT:

1. a. voltage is the same across each branch.
2. b. total current is equal to the sum of the branch currents.
3. a. $R_{eq} = R/N$
4. c. 75 V.
5. d.

$$I_{R1} = \frac{E}{R1} + \frac{75}{20,000} = \underline{3.75 \text{ mA}}$$

$$I_{R2} = \frac{E}{R2} + \frac{75}{30,000} = \underline{2.5 \text{ mA}}$$

$$I_{R3} = \frac{E}{R3} + \frac{75}{60,000} = \underline{1.25 \text{ mA}}$$

6. c. exactly 10 K

$$\begin{aligned} R_{eq} &= \frac{1}{\frac{1}{20} + \frac{1}{30} + \frac{1}{30}} \\ &= \frac{1}{0.05 + 0.033 + 0.016} \end{aligned}$$

$$= \frac{1}{0.1} = \underline{10 \text{ K}}$$

7. d. 7.5 mA

$$I = \frac{E}{R_{eq}} = \frac{75}{10,000}$$

$$I = \underline{7.5 \text{ mA}}$$

8. c. both a and b are correct.

9. c. 3 W

$$P_{R1} = \frac{E^2}{R1} = \frac{20^2}{200} = \frac{400}{200} = 2 \text{ W}$$

$$P_{R2} = \frac{400}{400} = 1 \text{ W}$$

$$P_T = P_{R1} + P_{R2} = 2 + 1 = \underline{3 \text{ W}}$$

10. d. 0.15 A

$$I = \frac{W}{E} = \frac{3}{20} = \underline{0.15 \text{ A}}$$

EXPERIMENT NO. 22 - PARALLEL RESISTORS

QUESTIONS:

3. Apply power, read the milliammeter and record the current below.

$$I_T = \underline{9.0} \text{ mA}$$

4.
$$R_{eq} = \frac{V_s}{I_T}$$

$$= \frac{(9 \text{ V})}{(9 \text{ mA})}$$

$$R_{eq} = \underline{1.0} \text{ K}$$

Observe that R_{eq} is less than 2.2 K, the lowest value in the network.

5.
$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2}}$$

Enter the resistance in K ohms.

$$R_{eq} = \frac{1}{\frac{1}{(2.2)} + \frac{1}{(3.3)} + \frac{1}{(4.7)}}$$

Solve with a calculator.

$$R_{eq} = \underline{1.03} \text{ K}$$

6. Compare the theoretical equivalent resistance of step 5 to that obtained in step 4. Are they close? Yes, they are very close.

8. Measure R_{eq} , as shown in Figure 4, using either a digital or analog ohmmeter and enter the reading below.

$$R_{eq \text{ MEASURED}} = \underline{1.027 \text{ K}}$$

Compare the measured resistance to that obtained in step 4 and 5. Are they all close in value? Yes

ASSIGNMENT:

1.

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(10)(3.3)}{(10 + 3.3)}$$

$$= \frac{33}{13.3} = \underline{2.48 \text{ K}}$$

2.

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{10} + \frac{1}{5} + \frac{1}{20}}$$

$$= \frac{1}{(0.1) + (0.2) + (0.05)} = \frac{1}{0.35} = \underline{2.86 \Omega}$$

3.

$$R_{eq} = \frac{1}{\frac{1}{1} + \frac{1}{2} + \frac{1}{4} + \frac{1}{8}} = \frac{1}{(1) + (0.5) + (0.25) + (0.125)}$$

$$= \frac{1}{1.875} = 0.533 \text{ K} = \underline{533 \Omega}$$

4.

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(10)(40)}{(10) + (40)} = \frac{400}{50} = \underline{8 \text{ K}}$$

EXPERIMENT NO. 23 - SERIES-PARALLEL CIRCUITS

QUESTIONS:

1. Measure the voltage at +V2 using the Ed-Lab panel voltmeter, as shown in Figure 3, and enter the reading in box below.

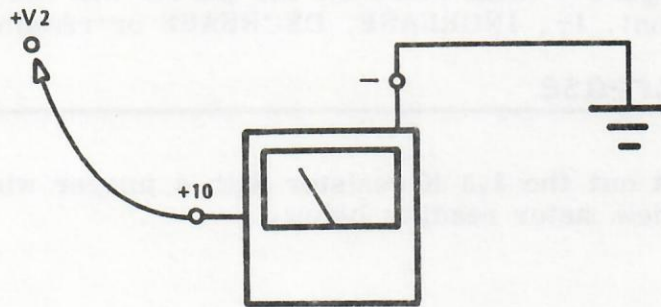


Figure 3 - Voltage reading of +V2; EXPERIMENT.

+V2 = 9.0 V

3. Apply power and read the current on the meter using the 0-5 scale. Record the reading below.

I_T = 2.5 mA

4. Using Ohm's Law, calculate the actual equivalent resistance of the circuit of Figure 3 from:

$$R_{eq} = \frac{V_s}{I_T}$$

Substitute the voltage and current from steps 1 and 3. Recall that using I_T in mA will produce an answer in K ohms.

$$R_{eq} = \frac{(9) \text{ V}}{(2.5) \text{ mA}}$$

Using a calculator determine the equivalent resistance and enter it below.

R_{eq} = 3.6 K

6. How does the measured resistance in step 4 compare with the calculated resistance from step 5 above? The

measured value is close to the calculated value.

7. If R3, the 3.3 K resistor is shorted out in the circuit of Figure 4 (still wired on the panel) will the total current, I_T , INCREASE, DECREASE or remain the same? _____

Increase

8. Short out the 3.3 K resistor with a jumper wire. Record the new meter reading below.

$$I_X = \underline{3.7} \text{ mA}$$

9. Calculate the new equivalent resistance based on:

$$\begin{aligned} R_{eq \text{ NEW}} &= \frac{V_2}{I_X} \\ &= \frac{(9.0) \text{ V}}{(3.7) \text{ mA}} \end{aligned}$$

$$R_{eq \text{ NEW}} = \underline{2.43} \text{ K}$$

10. Calculate the theoretical expected value of R_{eq} with the 3.3 K shorted out. Use your calculator.

$$R_{eq \text{ NEW}} = \underline{2.49} \text{ K}$$

11. How does measurement from step 9 compare to the theoretical calculation of step 10? It is very close to
the calculated value.

ASSIGNMENT:

1. T.
2. F. The total current does not flow through R4 and R5 as they are in parallel.
3. F. The first step is to find the parallel equivalent of R4 and R5.
4. F.

$$\begin{aligned} R_{eq} &= R_1 + R_2 + R_3 + \frac{(R_4)(R_5)}{R_4 + R_5} \\ &= 10 + 50 + 16 + \frac{(60)(40)}{(60) + (40)} \\ &= 10 + 50 + 16 + 24 \\ R_{eq} &= \underline{100 \Omega} \end{aligned}$$

5. T.

$$I_T = \frac{V_S}{R_{eq}} = \frac{100}{100} = \underline{1 \text{ A}}$$

6. a.

$$\begin{aligned} R_a &= R_2 + R_3 \\ &= 700 + 300 = 1000 \end{aligned}$$

$$R_b = \frac{1000}{2} = 500$$

$$R_{eq} = 500 + 100 + 500 = \underline{1100 \Omega}$$

b.

$$\begin{aligned} I_T &= V_S / R_{eq} \\ &= 44 / 1100 = 0.04 \text{ A} = \underline{40 \text{ mA}} \end{aligned}$$

c.

$$\begin{aligned} E_{R1} &= R1 I_T \\ &= (100)(0.04) = \underline{4 \text{ V}} \end{aligned}$$

$$\begin{aligned} E_{R2} &= R2 I_T \\ &= (500)(0.04) = \underline{20 \text{ V}} \end{aligned}$$

7. a.

$$R_a = \frac{R4 R5}{R4 + R5} = \frac{(30)(60)}{(30) + (60)} = \underline{20 \Omega}$$

$$\begin{aligned} R_{eq} &= R1 + R2 + R3 + R_a \\ &= 75 + 25 + 80 + 20 \\ &= \underline{200 \Omega} \end{aligned}$$

b.

$$I_T = \frac{V_S}{R_{eq}} = \frac{100}{200} = \underline{0.5 \text{ A}}$$

c.

$$\begin{aligned} E_{R3} &= I_T R3 \\ &= (0.5)(80) \\ &= \underline{40 \text{ V}} \end{aligned}$$

EXPERIMENT NO. 24 - KIRCHHOFF'S CURRENT LAW

QUESTIONS:

2. Use the voltmeter on the Ed-Lab panel to measure the voltage drop across each resistor and enter the data in the column marked VOLTAGE READINGS in Table 1.

CHECK POINT	ACROSS RESISTOR	VOLTAGE READINGS	CALCULATED CURRENT	
VA	R1 1 K	1.6	I_1	1.6
VB	R2 2.2 K	2.2	I_2	1.0
	R3 3.3 K	2.2	I_3	0.66
VC	R4 10 K	5.2	I_4	0.52
	R5 4.7 K	5.2	I_5	1.11

TABLE 1 - Voltage drops and currents in Figure 2.

3. Calculate the current flow through each resistor using Ohm's Law ($I = E/R$) and enter the answers in the right hand column of Table 1.

$$I_1 = \frac{(1.6)}{1000} = 1.6 \text{ mA}$$

$$I_2 = \frac{(2.2)}{2200} = 1.0 \text{ mA}$$

$$I_3 = \frac{(2.2)}{3300} = 0.66 \text{ mA}$$

$$I_4 = \frac{(5.2)}{10000} = 0.52 \text{ mA}$$

$$I_5 = \frac{(5.2)}{4700} = 1.11 \text{ mA}$$

4. Enter each of the calculated currents from Table 1 in the drawing of Figure 3.

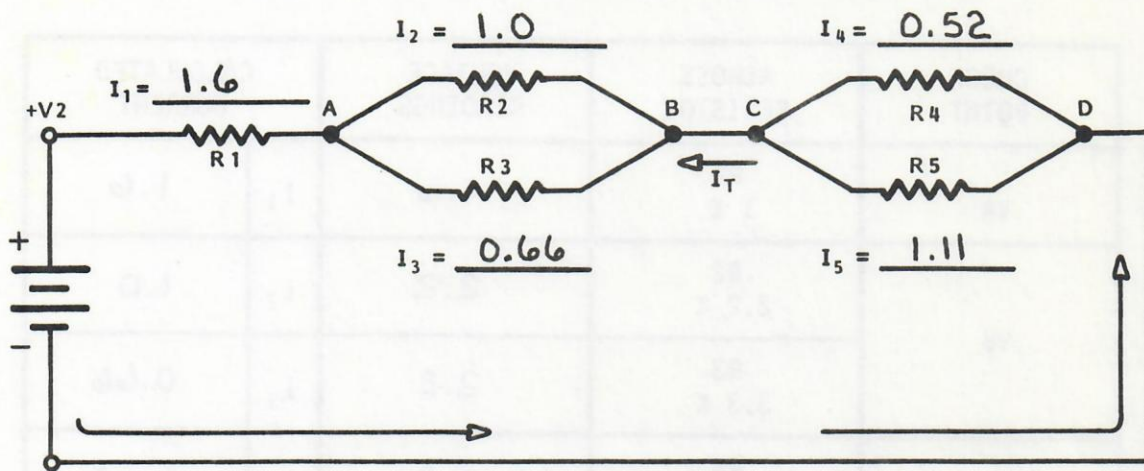


Figure 3 - Current distribution and node locations for the circuit of Figure 2; EXPERIMENT.

5. Using the data in Figure 3, determine I_T from I_1 .

$$I_T = I_1 = \underline{1.6} \text{ mA}$$

Next, determine I_T from the sum of I_2 and I_3 and also from I_4 and I_5 .

$$\begin{aligned} I_T &= I_2 + I_3 \\ &= (1.0) + (0.66) \\ I_T &= \underline{1.66} \text{ mA} \end{aligned}$$

or

$$\begin{aligned} I_T &= I_4 + I_5 \\ &= (0.52) + (1.11) \\ I_T &= \underline{1.63} \text{ mA} \end{aligned}$$

7. Read the current and enter it in the box below.

$$I_T \text{ MEASURED} = \underline{1.65 \text{ mA}}$$

Does the measured I_T from above agree closely with the calculated I_T from step 5? Yes

8. Read the entering and exiting currents at nodes A, B and C in Figure 3 and list them in Table 2.

NODE	CURRENTS		ALGEBRAIC TOTAL
	ENTERING	EXITING	
A	+1.66	-1.6	0.06
B	+1.63	-1.66	0.03
C	+1.63	-1.63	0.0

TABLE 2 - Node currents.

10. Are the total currents entering and leaving each node equal? Yes, they are very close.

Does the total algebraic current equal zero thus validating Kirchhoff's Current Law? Yes

ASSIGNMENT:

- c. 9 mA.
- c. 9 mA.
- b. 30 V.

$$\begin{aligned}
 E &= I_{R1} \cdot R1 \\
 &= (0.003)(10,000) \\
 &= \underline{30 \text{ V}}
 \end{aligned}$$

4. a. 5 K

$$R_2 = \frac{E_{R1}}{I_{R2}} = \frac{30}{0.006}$$

$$= \underline{5000 \Omega}$$

5. c. 9 mA.

6. (a) $I_T = 0.012 \text{ A} = 12 \text{ mA}$

$$I_T = I_{R1} + I_{R2} = \frac{E_{R1}}{R_1} + \frac{E_{R2}}{R_2}$$

$$= \frac{24}{6000} + \frac{24}{3000}$$

$$= 0.004 + 0.008 = \underline{0.012 \text{ A}}$$

(b) $I_{R5} = 8 \text{ mA}$

$$I_{R5} = I_T - I_{R4}$$

$$= 0.012 - 0.004$$

$$I_{R5} = \underline{0.008 \text{ A}}$$

(c) $R_5 = 6 \text{ K}$

$$R_5 = \frac{E_{R4}}{I_{R5}} = \frac{(I_{R4})(R_4)}{(I_T - I_{R4})}$$

$$= \frac{(0.004)(12000)}{(0.012 - 0.004)} = \frac{48}{0.008}$$

$$R_5 = \underline{6000 \Omega}$$

(d) $R_3 = 3 \text{ K}$

$$R_3 = \frac{E_{R3}}{I_{R3}} = \frac{V_S - V_{R1} - V_{R4}}{I_T}$$
$$= \frac{(108) - (24) - (48)}{0.012} = \frac{36}{0.012}$$

$R_3 = \underline{3000 \Omega}$

(e) $R_{eq} = 9 \text{ K}$

$$R_{eq} = \frac{V_S}{I_T} = \frac{108}{0.012} = \underline{9000 \Omega}$$

EXPERIMENT NO. 25 - VOLTMETER CIRCUITS

QUESTIONS:

2. Read the current flowing in the circuit on the 0-50 scale of the meter and enter the data below.

I WITH 470 K	$I_{\text{Meter}} = \underline{19.0} \mu\text{A}$
-----------------	---

3. Substitute other resistors for R1 as indicated in Table 1. Read the current for each resistor on the 0 to 50 μA scale and enter the data below.

There will be an overscale reading for some resistance values because the current will be greater than 50 μA .

R1	CURRENT (I_M)
1 M	9.0
4.7 M	3.0
100 K	over scale
33 K	over scale

TABLE 1 - I_M versus R1.

Which resistors produce overscale readings? 100K and 33K

4.

$$E = I (R_1 + R_M)$$

$$= (19 \mu\text{A})(0.475 \text{ M})$$

$E = \underline{9.025} \text{ V}$

5.

$$E = (I_{\mu\text{A}})(R_{\text{MEGS}})$$

$$= (9 \mu\text{A})(1 \text{ M}\Omega)$$

$E = \underline{9.0} \text{ V}$

6.
$$R_M = \frac{E_{FS}}{I_{MFS}}$$
$$= \frac{(10)}{(0.05)}$$

$R_M = 200 \text{ K}$

8. Apply power and record the voltage reading taken directly from the 1-10 scale.

$E = 8.8 \text{ V}$

Is the reading 9 V? No, it is slightly lower.

11. Shut off the power, disconnect the leads from the 1 M pot. Use the digital ohmmeter to measure resistance between the Red and Yellow jacks and record it below.

$R_{POT} = 92 \text{ K}$

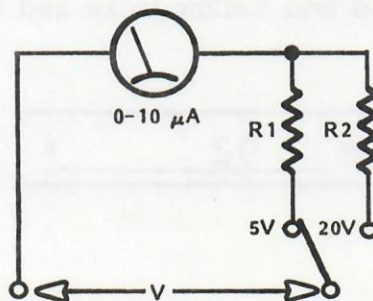
12. Record the resistance reading below.

$R_M = 4.8 \text{ K}$

How does this reading compare to the 5 K specified? It is slightly lower.

ASSIGNMENT:

1. T.
2. T.
3. F. The pointer of a D'Arsonval meter is attached to the center post of the bobbin (the moving coil).
4. T.
5. F. It may also be used as a voltmeter if a multiplier resistor is used.
6. T.
7. T.
8. F. It is called a multiplier resistor.
9. F. The required resistor is 200 K.
10. T.
11. F. A 0-1 mA meter has a sensitivity of $1 \text{ K}\Omega/\text{V}$ while a 0-100 μA movement will have a sensitivity of $10 \text{ K}\Omega/\text{V}$.
12. T.
13. (a)



$$(b) \quad R_1 = \frac{E}{I} = \frac{5}{10 \mu\text{A}} = \underline{500 \text{ K}}$$

$$R_2 = \frac{E}{I} = \frac{20 \text{ V}}{10 \mu\text{A}} = \underline{2 \text{ Megs}}$$

$$(c) \quad S = \frac{\Omega}{V} = \frac{500 \text{ K}}{5} = \frac{2 \text{ M}}{20}$$

$$= \underline{100 \text{ K}\Omega/\text{V}}$$

EXPERIMENT NO. 26 - AMMETER CIRCUITS

QUESTIONS:

2. Read the current flow indicated by the meter on the 0-50 μA scale and record it below.

$$I_M = \underline{45} \mu\text{A}$$

8. Read the meter directly on the 0 to 5 scale and record the current flow in the box below. Note that each division equals 0.1 mA.

$$I_{\text{CIRCUIT}} = \underline{4.2} \text{ mA}$$

Does the current reading agree with the calculated value from step 6? Yes, it is very close.

Why doesn't the 5 K meter resistance upset or affect the readings taken? Because it is much larger than the 50 Ω shunt.

11.

$$R_S = \frac{I_{\text{FS OLD}}}{I_{\text{FS NEW}}} R_M$$

$$= \frac{(0.05 \text{ mA})}{(10 \text{ mA})} (5000)$$

FOR 10 mA FULL SCALE	$R_S = \underline{25} \Omega$
-------------------------	-------------------------------

13. Apply power, read the current on the 0-10 scale and record it below.

$$I_M = \underline{9.1} \text{ mA}$$

Is this the correct reading? Yes, it is close.

ASSIGNMENT:

1. T.

$$I_{RS} = I_T - I_M$$

$$= 5 - 1 = \underline{4 \text{ mA}}$$

2. F. It is placed in parallel.

3. F. A shunt cannot decrease the range of a meter, only increase it.

4. T.

5. T.

$$I_{FS \text{ NEW}} = I_{FS \text{ OLD}} \left(\frac{R_M}{R_S} \right)$$

$$= 100 \mu\text{A} \left(\frac{1000}{200} \right)$$

$$= 500 \mu\text{A} = \underline{0.5 \text{ mA}}$$

6.

$$R_S = \left(\frac{I_{FS \text{ OLD}}}{I_{FS \text{ NEW}}} \right) R_M$$

$$= \left(\frac{0.5}{100} \right) 1500 = \underline{7.5 \Omega}$$

The more accurate formula, shown below, is not needed because the difference in results is so small.

$$R_S = \frac{R_M}{\frac{I_{FS \text{ NEW}}}{I_{FS \text{ OLD}}} - 1} = \frac{1500}{\left(\frac{100}{.5} \right) - 1} = \underline{7.5376 \Omega}$$

$$7. \quad I_{FS \text{ NEW}} = I_{FS \text{ OLD}} \left(\frac{R_M}{R_S} \right)$$

$$= 50 \mu A \left(\frac{4000}{10} \right)$$

$$I_{FS \text{ NEW}} = 20,000 \mu A = \underline{20 \text{ mA.}}$$

Resistance (Ω)	Current (mA)	Power (mW)
10	2.0	0.4
20	1.0	0.2
30	0.67	0.15
40	0.50	0.125
50	0.40	0.10
60	0.33	0.083
70	0.29	0.071
80	0.25	0.0625
90	0.22	0.055
100	0.20	0.05
150	0.13	0.0325
200	0.10	0.025
300	0.067	0.015
400	0.050	0.0125
500	0.040	0.010
600	0.033	0.0083
700	0.029	0.0071
800	0.025	0.00625
900	0.022	0.0055
1000	0.020	0.005

TABLE 1: Current values for various values of R_S in the circuit of Figure 1.

EXPERIMENT NO. 27 - OHMMETER CIRCUITS

QUESTIONS:

4. Read the meter on the 50 μA scale and record the current below.

I_M WITH $R_X = 10K$	$I_M =$ <u>25</u> μA
---------------------------	---------------------------------

Does the current flow equal 25 μA or half scale as described in step 3 above? Yes

5. You will now test the ohmmeter scale. Connect each resistor listed in Table 1 to the B1 and B2 terminals in turn. Record the current reading from the 50 μA scale in column A of Table 1.

	A	B
R_X	I_M (μA)	RES. SCALE (Ω)
100	49.5	50
1 K	46	1 K
2.2 K	42	2.1 K
3.3 K	38.5	3.1 K
4.7 K	34.5	4.7 K
10 K	25	10 K
15 K	20	15 K
22 K	15.5	22 K
33 K	12.0	31 K
56 K	8.0	54 K
100 K	5.0	95 K
470 K	1.5	450 K

TABLE 1 - Current versus resistance for various values of R_X in the circuit of Figure 4.

7. You will now add calibration markings for 4 additional resistors. Connect the 4 resistor values listed in Table 2 into the ohmmeter circuit (between B1 and B2) and record the current readings.

R_X	COMBINATION	$I_M (\mu A)$
200		48.5
6.6 K		31
20 K		16.5
1 MEG		1.0

TABLE 2 - Resistance combinations to further calibrate the scale in Figure 6.

8. Mark the scale in Figure 6 to indicate the resistance readings for the resistors listed in Table 2.

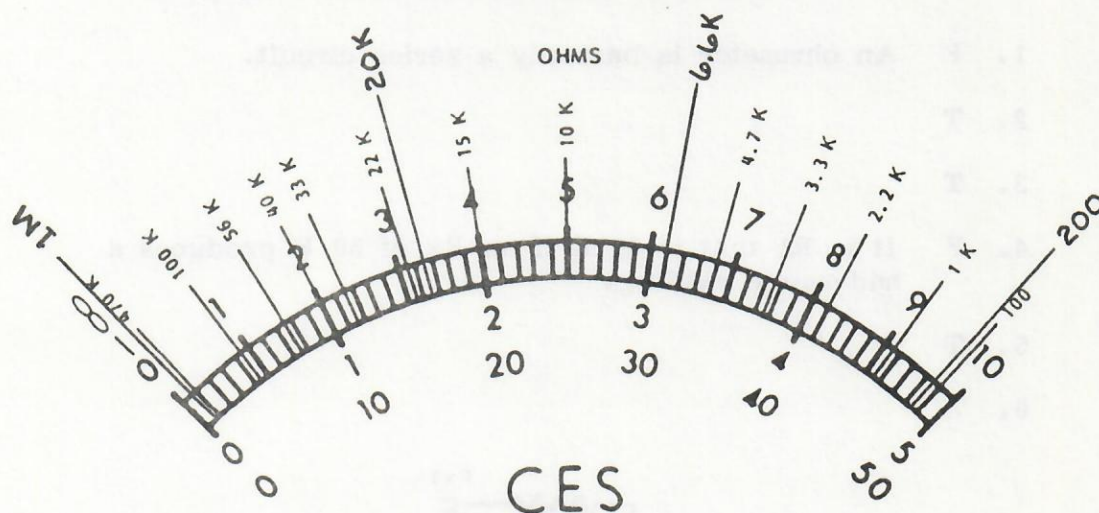


Figure 6 - Ed-Lab panel meter calibrated to read resistance.

11. Connect the resistors, listed below in Table 3, to the B1, B2 terminals and record the scale readings in current and resistance.

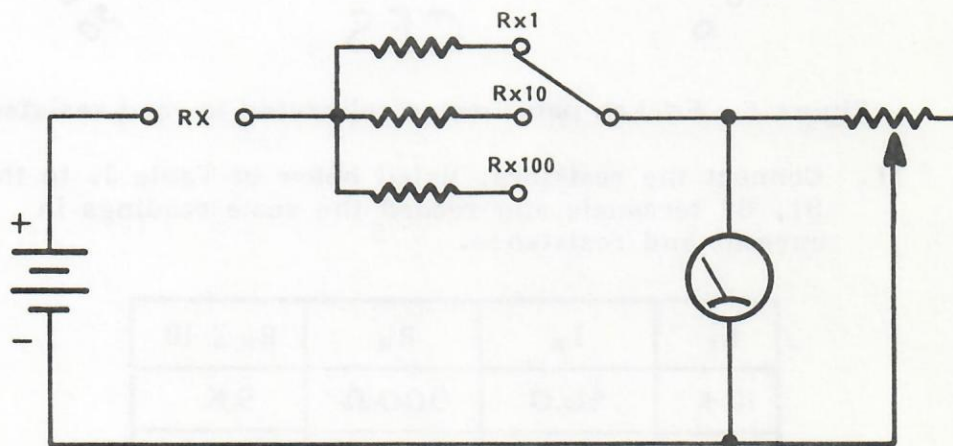
R_X	I_M	R_M	$R_M \times 10$
10 K	46.0	900 Ω	9 K
100 K	25	10 K	100 K
1 M	5	95 K	0.95 M

TABLE 3 - Current versus resistance for the $R_X \times 10$ circuit of Figure 6.

12. What conclusion can you draw from the results of Table 2?
The ohmmeter scale can be extended by
increasing the series resistors.
13. Is the resistance scale linear? No, the scale is non-linear.
Describe the scale calibration. The scale is "crowded"
at the high end.

ASSIGNMENT:

1. F An ohmmeter is basically a series circuit.
2. T
3. T
4. F It is R_1 that is 50 K if an R_x of 50 K produces a mid-range reading.
5. T
- 6.



EXPERIMENT NO. 28 - VOLTMETER LOADING

QUESTIONS:

2. Connect two leads to the panel voltmeter for the +10V range. Measure +V2 and record it below.

$$+V2 = \underline{9.0} \text{ V}$$

3. Now, measure V_O and record it below.

$$V_O = \underline{6.2} \text{ V}$$

4. Calculate the expected V_O .

$$V_O = (V_S) \frac{R_2}{R_1 + R_2}$$

$$= (9.0) \frac{2.2}{1 + 2.2}$$

$$V_O = \underline{6.18} \text{ V}$$

Compare the calculated value for V_O to the measured value from step 3. Are they close? Yes

Does there seem to be a meter loading problem? No

Explain why or why not. The meter resistance is high compared to 2.2K, so the meter does not "load" the 2.2K resistor.

6. Calculate the expected value of V_O using V_S , measured earlier in step 2 as +V2.

$$V_O = (V_S) \frac{R_2}{R_1 + R_2}$$
$$= (9.0) \frac{100}{470 + 100}$$

$$= (9.0) (0.176)$$

$$V_{O \text{ CALC.}} = \underline{1.58} \text{ V}$$

7. Connect the Ed-Lab 0 to 5 volt range voltmeter across V_O and record the reading below.

$$V_{O \text{ MEAS.}} = \underline{1.2} \text{ V}$$

How does this compare with the expected unloaded output calculated in step 6? The voltage reading is lower than the calculated value due to the meter loading.

8. Calculate the expected V_O taking the 100 K resistance of the voltmeter into account as follows:

The meter resistance, 100 K, in parallel with R_2 , also 100 K is effectively 50 K. Thus

$$V_{O \text{ exp}} = (V_S) \frac{R_2}{R_1 + R_2}$$
$$= (9.0) \frac{50}{470 + 50}$$

$$= (9.0) (0.096)$$

$$V_{O \text{ exp}} = \underline{0.86} \text{ V}$$

How does this computed value, taking the loading into account, compare to the actual measured voltage from step 7? It is lower than the actual measured value.

9. Disconnect the Ed-Lab panel meter and measure V_O using any high resistance meter such as a Digital or Transistor voltmeter.

Enter the voltage reading below.

DIGITAL V M	$V_O = \underline{1.587} \text{ V}$
----------------	-------------------------------------

How does this measurement of V_O compare to the calculated value from step 6? It is very close to the calculated value.

ASSIGNMENT:

1. c. 15 V

$$V_O = 25 \left(\frac{R_2}{R_1 + R_2} \right) = 25 \left(\frac{30}{50} \right) = \underline{15 \text{ V}}$$

2. d. 10.7 V

$$R_M = 1K \times 30 = 30 \text{ K}$$

$$V_O = 25 \left(\frac{R_{\text{eff}}}{R_1 + R_{\text{eff}}} \right) = 25 \left(\frac{15}{20 + 15} \right) = \underline{10.7 \text{ V}}$$

3. c. 15 V.

4. a. low resistances.

5. b. ohms per volt rating.

4. Compared to the low level water and pressure of water, the high resistance water such as a liquid or hydraulic system.

Enter the range reading from:

Initial V	Final V = 1.087
--------------	--------------------

How does the measurement of V_a compare to the calculated value? V_a is very close to the calculated value.

ASSIGNMENT

1. 12 V

$$V_a = \frac{R_2}{R_1 + R_2} \left(\frac{V_s}{R_1} \right) = \frac{10}{10 + 10} \left(\frac{12}{10} \right) = 0.6 \text{ V}$$

2. 10 V

$$R_T = R_1 + R_2 = 10 + 10 = 20 \text{ k}$$

$$V_a = \frac{R_2}{R_1 + R_2} \left(\frac{V_s}{R_1} \right) = \frac{10}{10 + 10} \left(\frac{10}{10} \right) = 0.5 \text{ V}$$

3. 12 V

4. 10 V

5. 10 V

Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

DC CIRCUITS & THEOREMS

UNIT E5

Ed-Lab 651

INSTRUCTOR'S ANSWER MANUAL

DC CIRCUITS & THEOREMS

UNIT 65

UNIT E5 - DC CIRCUITS & THEOREMSINSTRUCTOR'S ANSWER MANUAL

EXPERIMENT NO. 29 - MAXIMUM POWER TRANSFER

QUESTIONS:

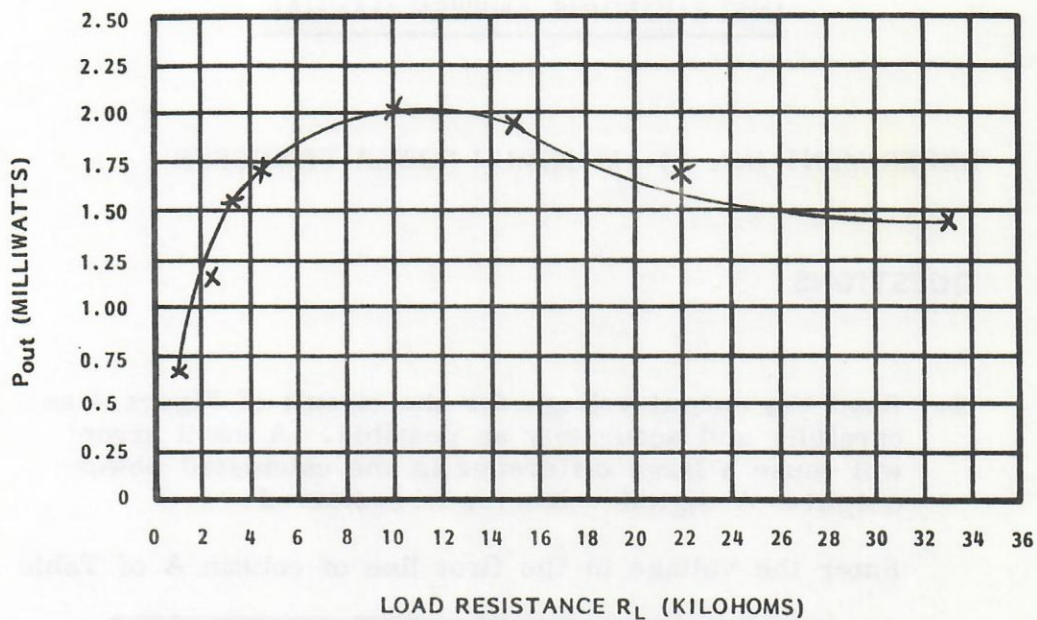
2. Read the output voltage for the circuit of Figure 4 as carefully and accurately as possible. A small error will cause a large difference in the calculated power output. A digital voltmeter is preferred.

Enter the voltage in the first line of column A of Table 1.

R_L	(A) E_{out} (V)	(B) P_{out} (mW)
1 K	0.810	0.65
2.2 K	1.610	1.18
3.3 K	2.23	1.51
4.7 K	2.85	1.73
10 K	4.51	2.03
15 K	5.40	1.94
22 K	6.19	1.74
33 K	6.87	1.43
56 K	7.63	1.04
100 K	8.16	0.67

TABLE 1 - E_{out} and P_{out} versus R_L .

6. Plot P_{out} versus R_L for the resistance up to 33 K on the graph below.



7. Which load resistance provides maximum power output? 10 K

What is the relationship between R_L and R_i at maximum power output? They are equal.

ASSIGNMENT:

- c. load resistance is equal to R_i .
- d. 100 ohms.
- d. all of the above.
- a. also increase.
- 5.

$$R_L = R_i = 2 \text{ K}$$

$$W_{RL} = E^2 / R$$

$$= 5^2 / 2 \text{ K}$$

$$W_{RL} = \underline{0.0125 \text{ watts}}$$

EXPERIMENT NO. 30 - WHEATSTONE BRIDGE

QUESTIONS:

2. Read the knob pointer position (0 to 10) and estimate the unknown resistance, R_X , based on 10 K per knob division.

$$R_X = 27.5 K$$

How does the measured value of R_X compare to the 33 K resistor used? It is much lower because the

potentiometer knob markings are not
calibrated accurately.

3. Substitute various "unknown" resistors for R_X , in the bridge, as listed in Table 1.

Null each resistance and enter the R_A knob setting in Table 1.

R_X	R_A SETTING	ESTIMATED R_X
10 K	1.0	10K
15 K	1.3	13 K
22 K	2.0	20K
33 K	2.8	28K
56 K	4.5	45K
100 K	9.0	90K
470 K	(NULL NOT POSSIBLE)	

TABLE 1 - Null settings for different values of R_X .

How do the measured results compare to the actual resistance values? The measured results are not

very accurate because the knob markings are
not calibrated.

6. Use the 470 K resistor for R_X , null the bridge and complete Table 2, below.

R_A NULL POSITION	R_A (0-100 K) RESISTANCE	R_X ($R_A \times 10$)
4.0	40 K	400 K

TABLE 2 - Data for $R_X = 470$ K.

How does the measured value of R_X compare to the 470 K resistor used? It is lower because the knob

markings are not calibrated.

10. Place switch S_A in the DOWN position and record the voltage reading.

$$V_{SA \text{ DOWN}} = \underline{1.5} \text{ V}$$

11. Calculate the expected no load voltage from point A to ground using the voltage divider formula.

$$E_A = (V_S) \frac{R_2}{R_1 + R_2}$$

$$= (9) \frac{100}{100 + 470}$$

$$E_A = \underline{1.58}$$

How does the calculated value of E_A compare to the measured value? It is close.

13. Wave your hand over the photocell keeping a distance of approximately one foot and try to read the small voltage change (ΔE)*. Record the voltage change in the box below:

$$\Delta E = \underline{0.1} \text{ V}$$

16. Wave your hand across the photocell at a distance of approximately one foot. Observe and record the voltage change.

$$\Delta E = 0.5 \text{ V}$$

Can you now see a greater variation in the meter pointer movement than before? Yes

ASSIGNMENT:

1. F. V_A will only be half of V_S when R_1 equals R_2 .
2. T.
3. T

$$\frac{7 \text{ K}}{80 \text{ K}} = \frac{21 \text{ K}}{240 \text{ K}}$$

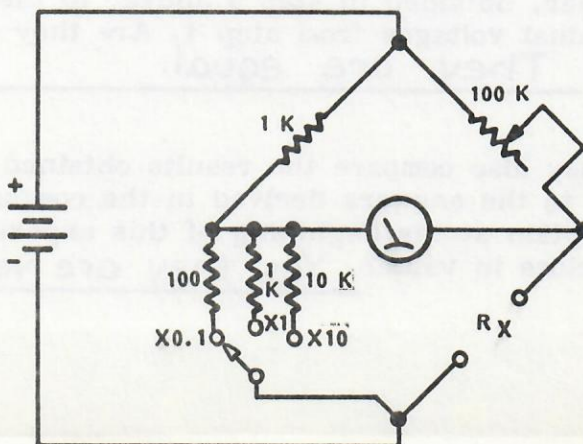
4. F. The bridge will balance when

$$\frac{R_1}{R} = \frac{R_3}{R_4}$$

but not as show in the question.

5. T.
6. F. If V_{R2} is +5 V, for balance V_{R4} must also be +5 V.
7. F. It is necessary to increase R_2 by 10 times. Increasing R_1 by 10 times reduces the scale by a factor of 10.
8. T.
9. T.

10.



EXPERIMENT NO. 31 - SUPERPOSITION THEOREM

QUESTIONS:

2. Read the voltmeter and enter the voltage reading in the first line of Table 1.

NO.	SWITCH S_A	SWITCH S_B	SOURCE	V_{out} (V)
1	UP	UP	NEITHER	0
2	DOWN	UP	V_A (+5 V)	+2.35
3	UP	DOWN	V_B (+9 V)	+1.95

TABLE 1 - Individual output voltages for the circuit of Figure 4.

4. Calculate the sum of lines 2 and 3 in Table 1 algebraically and enter the answer below.

$$V_0 = \underline{4.30} \text{ V}$$

5. Set switches A and B as shown in Table 2 below. This will apply both voltage sources at the same time.

SWITCH S_A	SWITCH S_B	SOURCE	V_{out}
DOWN	DOWN	$V_{S1} + V_{S2}$	<u>4.3</u> V

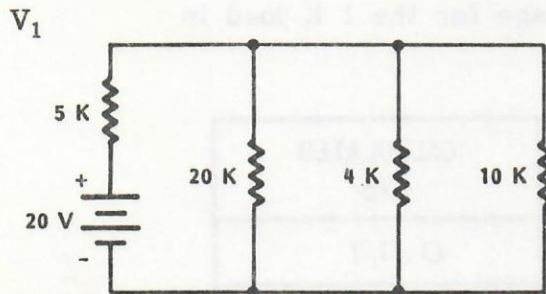
TABLE 2 - V_0 for both voltage sources.

Read the meter and record the output voltage and polarity in Table 2 above.

6. Compare the measured V_0 from the two voltage sources together, obtained in step 5 above, to the sum of the individual voltages from step 4. Are they equal or close? They are equal.
7. You may also compare the results obtained in steps 3, 4 and 5 to the answers derived in the computations in the description at the beginning of this experiment. Are they close in value? Yes they are very close.

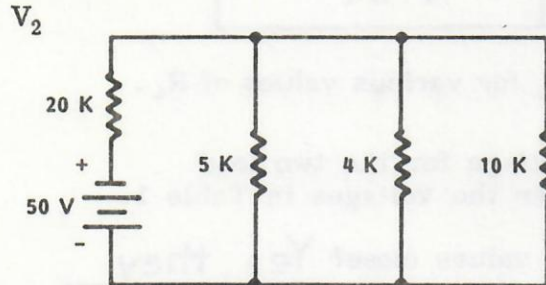
ASSIGNMENT:

1. F. Two of the three voltage sources must be shorted out.
2. T.
3. F. If the Superposition Theorem is not used Simultaneous equations are used. The theorem permits the use of Ohm's Law.
4. T.
- 5.



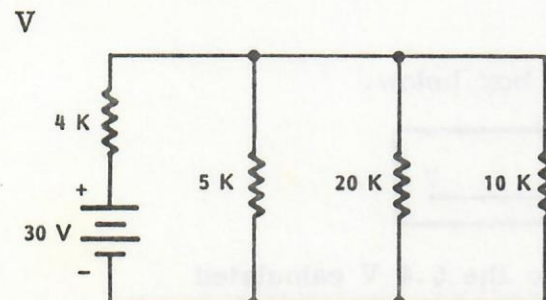
$$R_{eq} = \frac{1}{\frac{1}{20} + \frac{1}{4} + \frac{1}{10}} = 2.5 \text{ K}$$

$$V_O = \frac{2.5 \text{ K}}{2.5 \text{ K} + 5 \text{ K}} (20) = \underline{+ 6.66 \text{ V}}$$



$$R_{eq} = \frac{1}{\frac{1}{5} + \frac{1}{4} + \frac{1}{10}} = 1.8 \text{ K}$$

$$V_O = \frac{1.8}{1.8 + 20} (-50) = \underline{-4.13 \text{ V}}$$



$$R_{eq} = \frac{1}{\frac{1}{5} + \frac{1}{20} + \frac{1}{10}} = 2.85 \text{ K}$$

$$V_O = \frac{2.85}{2.85 + 4} (30) = \underline{+12.5 \text{ V}}$$

Algebraic sum

$$\begin{array}{r} + 6.66 \\ - 4.13 \\ + 12.50 \end{array}$$

$$V_O = \underline{+ 15.03}$$

EXPERIMENT NO. 32 - THEVENIN'S THEOREM

QUESTIONS:

2. Apply power, measure V_O and record the voltage below.

$V_O = \underline{3.3} \text{ V}$

How close is the measured V_O to 3.37 V, calculated earlier in the description? It is very close.

Enter the calculated output voltage for the 1 K load in the first line of Table 1.

LOAD R_L	MEASURED V_O	CALCULATED V_O
1 K	0.8	0.77
15 K	3.8	3.85
22 K	4.15	4.24

TABLE 1 - Calculated and measured V_O for various values of R_L .

7. Calculate the expected output voltage for the two load resistors, 15 K and 22 K and enter the voltages in Table 1.

Are the measured and calculated values close? Yes, they are very close.

8. Record the measured V_{Th} in the box below.

$V_{Th} = \underline{5.2} \text{ V}$

How close is the measured V_{Th} to the 5.4 V calculated earlier? It is very close.

11. Adjust the 10 K pot until the voltmeter indicates an output voltage of one half of V_{Th} which is:

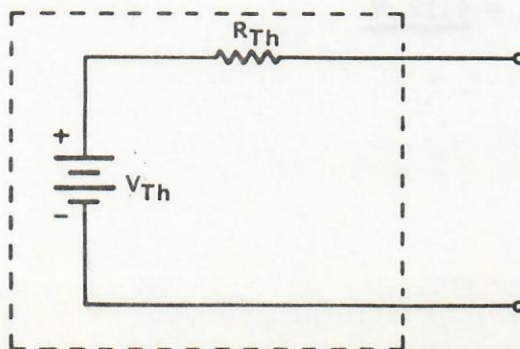
$$\frac{5.4}{2} = 2.7 \text{ V}$$

Refer to the panel markings for the 10 K pot and estimate the pot resistance based on 1 K per division. Record the resistance below.

$$R_{pot} = R_{Th} = \underline{6.23 \text{ K}}$$

ASSIGNMENT:

1. T.
2. F. It is necessary to remove R_L and measure V_{Th} or calculate it using the voltage divider formula.
3. T.
4. F. It is equal to $(V_S) R_2 / R_1 + R_2$ or
(20) $6/4 + 6 = \underline{12 \text{ V}}$.
5. T. $V_O = (V_{Th}) R_L / R_L + R_{Th}$
 $= (12) 20 / 20 + 12.4 = \underline{7.4 \text{ V}}$.
6. F. The open circuit voltage of 6 V is V_{Th} .
7. F. This indicates that R_{Th} is 6 K.
8. T.
- 9.



10.

a. V_{Th}

$$V_{Th} = (V_S) \frac{R_2}{R_1 + R_2}$$

$$= (20) \frac{2.2}{1 + 2.2}$$

$$V_{Th} = \underline{13.75 \text{ V}}$$

b. R_{Th}

$$R_{Th} = (R_1 \parallel R_2) + R_3 + R_4$$

$$= \frac{(1)(2.2)}{1 + 2.2} + 6.8 + 15$$

$$= \underline{22.48 \text{ K}}$$

c. V_O loaded

$$V_O = (V_{Th}) \frac{R_L}{R_{Th} + R_L}$$

$$= (13.75) \frac{10}{22.8 + 10}$$

$$V_O = \underline{4.19 \text{ V}}$$

EXPERIMENT NO. 33 - NORTON'S THEOREM

QUESTIONS:

2. Apply power, measure V_O and record it below in Table 1 in the line for $R_L = 50\Omega$.

R_L	V_O EXPECTED	V_O MEASURED
50Ω	45 mV	45 mV
100Ω	90 mV	90 mV
200Ω	180 mV	170 mV
1 K *	0.77 V	0.8 V

* Use the 5 V scale on the Ed-Lab meter.

TABLE 1 - V_O for different values of R_L .

3. Substitute the other load resistances listed in Table 1 and enter the output voltages, noting that you obtain a 100 ohm load by removing one of the parallel 100 ohm resistors and you place the two 100 ohm resistors on the panel in series for the 200 ohm load.

How do the measured values of V_O compare with the expected values of V_O ? The measured value is

close to the expected value.

5. Apply power, read the meter and record I_N below.

$I_N =$ 0.85 mA

Does the measured I_N agree with the I_N of 0.9 mA calculated earlier?

Note that the meter shunt acts as a 50 ohm load and not the "ideal" dead short.

The measured current is

close to the expected current.

ASSIGNMENT:

1. F. I_N and R_N are to be shown in parallel.

2. T.

$$R_T = (6 \text{ K} \parallel 6 \text{ K}) + 3 \text{ K} = 6 \text{ K}$$

$$I_T = E/R = 60/6 \text{ K} = 10 \text{ mA}$$

$$I_N = 10 \text{ mA}/2 = \underline{5 \text{ mA}}$$

3. F.

$$R_N = 3 \text{ K} \parallel 6 \text{ K} \parallel 6 \text{ K} = \underline{1.5 \text{ K}}$$

4. F. The milliammeter must be placed directly across the output in place of R_L .

5. T. When R_L is very much smaller than R_N the load current will be close to I_N , 5 mA.

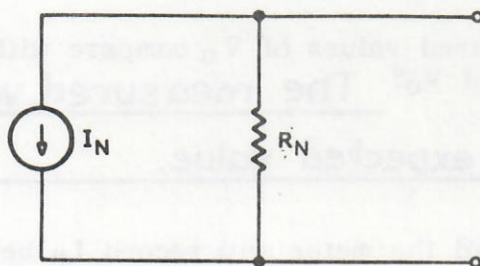
6. T. A 50 ohm load will carry I_N , thus

$$E_{50} = 50 \times 0.005 = \underline{0.25 \text{ V}}$$

7. T.

8. F. This has to be done only to determine R_N .

9.



10.

a. R_N is solved in the same manner as R_{Th} , by removing V_S and replacing it with a short. Thus

$$R_N = R_1 \quad R_2 = \frac{(12)(6)}{12 + 6} = \underline{4 \text{ K}}$$

- b. I_N is solved for by shorting out the load terminals. Thus:

$$R_T = R_1 + (R_2 \parallel R_3) = 12 + 4 = 16 \text{ K}$$

$$I_T = E/R_T = 160/16 \text{ K} = 10 \text{ mA}$$

$$I_N = I_{R_3} = E_{R_3}/R_3$$

Since

$$\begin{aligned} E_{R_3} &= 10 \text{ mA} \times (R_2 \parallel R_3) \\ &= 10 \text{ mA} \times 4 \text{ K} = 40 \text{ V} \end{aligned}$$

Thus

$$I_N = I_{R_3} = 40/12 \text{ K} = \underline{3.33 \text{ mA}}$$

- c.

$$E_O = I_N R_L$$

$$= (3.33 \text{ mA}) (10\Omega)$$

$$= \underline{0.0333 \text{ V}}$$

EXPERIMENT NO. 34 - DELTA-WYE CIRCUITS

QUESTIONS:

2. Apply power, measure V_O across the 15 K load and record the voltage below.

$$\Delta V_O = \underline{2.4} \text{ V}$$

4. Apply power, measure V_O across the 15 K load and record the voltage below.

$$\gamma V_O = \underline{2.4} \text{ V}$$

5. Compare V_O for the wye and delta circuits. How close are they? They are of the same value.

Are the delta and wye circuits equivalent? Yes

ASSIGNMENT:

1. F. The delta is the equivalent of the pi network.
2. F. The wye is the equivalent of the tee network.
3. T.
4. T.
5. F. The delta and wye circuits are used extensively in electrical power distribution circuits.
6. $R_{AB} = 4 \text{ K}$
 $R_{AC} = 6 \text{ K}$
 $R_{BC} = 6 \text{ K}$
7. $R_1 = 2 \text{ K}$
 $R_2 = 2 \text{ K}$
 $R_3 = 4 \text{ K}$

The following section contains the Unit Tests for E1 to E5 and the Unit Test Answer Keys. The Unit Tests may be duplicated as necessary. The tests are so designed that the Unit Test is reusable and only the Answer Sheets are expendable.

The following Unit Tests and Answer Keys are included:

- Unit E1 - DC Electricity Concepts
- Unit E2 - DC Electrical Circuits
- Unit E3 - DC Ohm's Law
- Unit E4 - DC Circuits and Laws
- Unit E5 - DC Circuits and Theorems

The following section contains the Unit Tests for E1 to E2 and the Unit Test Answer Keys. The Unit Tests may be distributed as necessary. The tests are designed so that the Unit Test is complete and only the answer keys are distributed.

The following Unit Tests and Answer Keys are included:

- Unit E1 - DC Electricity Concepts
- Unit E2 - DC Electrical Circuits
- Unit E3 - DC Circuit Law
- Unit E4 - DC Magnetic and Power
- Unit E5 - AC Circuits and Transformers

UNIT TEST - BOOK E1

DC ELECTRICITY CONCEPTS

UNIT TEST - BOOK 1

DC ELECTRICITY CONCEPTS

Answer the following True-False questions.

1. It is safe to cut off the ground pin of a 3 wire power plug if the outlet does not have the third pin. _____
2. Safety goggles must be worn even though a person wears corrective eyeglasses. _____
3. If a line cord has cracks in the insulation that piece of equipment should not be used. _____
4. Matter is any substance that occupies space, is solid, but not liquid. _____
5. A molecule is the smallest particle of a compound that still retains the compound's characteristics. _____
6. An element cannot be further reduced without changing its characteristics. _____
7. The nucleus of an atom contains protons, neutrons and electrons. _____
8. The nucleus of an atom is electrically positive. _____
9. Electrons that orbit the nucleus of an atom are equal in number to the protons in that nucleus. _____
10. The valence ring of an atom can hold anywhere from 0 to 8 electrons. _____
11. An Atomic Weight of 55 for an atom indicates that it has 55 electrons, 55 protons and 55 neutrons. _____
12. An electron may be moved out of its orbit by energy in the form of heat, light or radiation. _____
13. A valence electron moved out of its orbit is known as a free electron. _____
14. A good conductor has one valence electron, a semiconductor has two valence electrons and an insulator has three valence electrons. _____

15. The electrical pressure that forces an electron flow through a circuit is called an electromotive force and it is measured in Amperes.

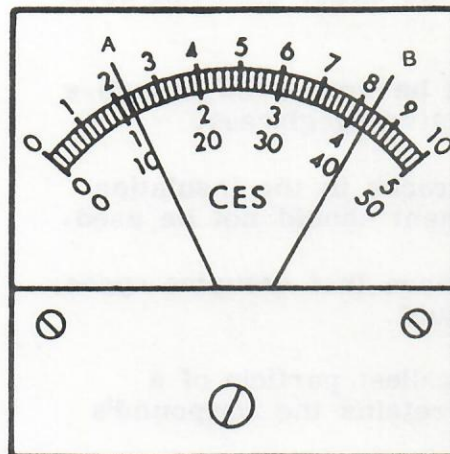


Figure 1 above refers to questions 16 to 18.

16. When on the 50 volt range, pointer A in the meter of Figure 1 is reading 11 volts.
17. When on the 10 volt range, pointer B in the meter of Figure 1 is reading 8.4 volts.
18. When on the 5 volt range, pointer A in the meter of Figure 1 is reading 1.2 volts.
19. Resistance in an electrical circuit is the opposition to the flow of current.
20. When measuring resistance with an Analog ohmmeter there can be no voltage present in the circuit but with a Digital ohmmeter voltage in the circuit is allowable.
21. On the meter face of an analog ohmmeter scale of a VOM, Infinity is on the right end of the scale and Zero ohms is on the left end.

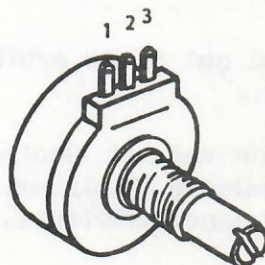
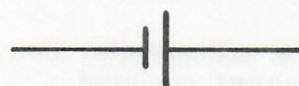


Figure 2 above refers to questions 22 and 23.

22. An ohmmeter is connected between pins 2 and 3 in Figure 2. Full clockwise rotation will give the maximum resistance of the pot. _____
23. The pot shown in Figure 2 is a 10 K unit. The arm of the pot is set at the mid-point. The resistance measured from 1 to 3 will be 5 K. _____
24. Three quarters of an ampere can be expressed as 0.75 A or 750 mA. _____
25. Electrons flow through a circuit at the effective velocity of 6.25×10^{18} mps. _____
26. When measuring current with a voltmeter it must be placed in series with the circuit being tested. _____
27. When connecting a voltmeter or ammeter into a circuit, polarity must be observed. _____
28. Electron flow and current flow are considered to be the same in the experiment manuals. _____
29. Electrons flow from plus to minus. _____
30. The current range of a milliammeter can be reduced by adding a shunt resistor. _____

31. Match the left column of answers to the right column.

 (A)	 (B)	_____ 1. Voltmeter
 (C)	 (D)	_____ 2. Lamp
 (E)	 (F)	_____ 3. Cell
 (G)	 (H)	_____ 4. SPDT switch
 (I)	 (J)	_____ 5. Ammeter
 (K)	 (L)	_____ 6. Battery
		_____ 7. Ohmmeter
		_____ 8. Variable Voltage
		_____ 9. Resistor
		_____ 10. Infinity
		_____ 11. Omega
		_____ 12. Potentiometer

32. Match the following.

- | | |
|----------------|--------------------------|
| A. 3 A | 1. _____ 0.005 μ A |
| B. 0.5 A | 2. _____ 0.001 mA |
| C. 2,700 V | 3. _____ 500,000 μ A |
| D. 0.000 002 V | 4. _____ 0.05 A |
| E. 50 mA | 5. _____ 3 000 mA |
| F. 100 μ A | 6. _____ 200 mV |
| G. 5 nA | 7. _____ 0.1 mA |
| H. 0.003 V | 8. _____ 2.7 kV |
| I. 1000 nA | 9. _____ 3 mV |
| J. 0.2 V | 10. _____ 2 μ V |

33. Draw the circuit of a voltage source, lamp load and switch in series.

Add a voltmeter that measures the load voltage and an ammeter that measures the load current. Show the necessary polarity for both meters.

2.1.1.1

1. 0.000 A	0.000 A
2. 0.000 A	0.000 A
3. 0.000 A	0.000 A
4. 0.000 A	0.000 A
5. 0.000 A	0.000 A
6. 0.000 A	0.000 A
7. 0.000 A	0.000 A
8. 0.000 A	0.000 A
9. 0.000 A	0.000 A
10. 0.000 A	0.000 A

2.1.1.2

2.1.1.3

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E1

1. _____ 7. _____ 13. _____ 19. _____ 25. _____

2. _____ 8. _____ 14. _____ 20. _____ 26. _____

3. _____ 9. _____ 15. _____ 21. _____ 27. _____

4. _____ 10. _____ 16. _____ 22. _____ 28. _____

5. _____ 11. _____ 17. _____ 23. _____ 29. _____

6. _____ 12. _____ 18. _____ 24. _____ 30. _____

31. 1. _____ 5. _____ 9. _____ 32. 1. _____ 6. _____

2. _____ 6. _____ 10. _____ 2. _____ 7. _____

3. _____ 7. _____ 11. _____ 3. _____ 8. _____

4. _____ 8. _____ 12. _____ 4. _____ 9. _____

5. _____ 10. _____

33.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET UNIT TEST 1

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

UNIT TEST - BOOK E2

DC ELECTRICAL CIRCUITS

UNIT TEST - 2002

DC ELECTRICAL CIRCUITS

Answer the following True-False questions.

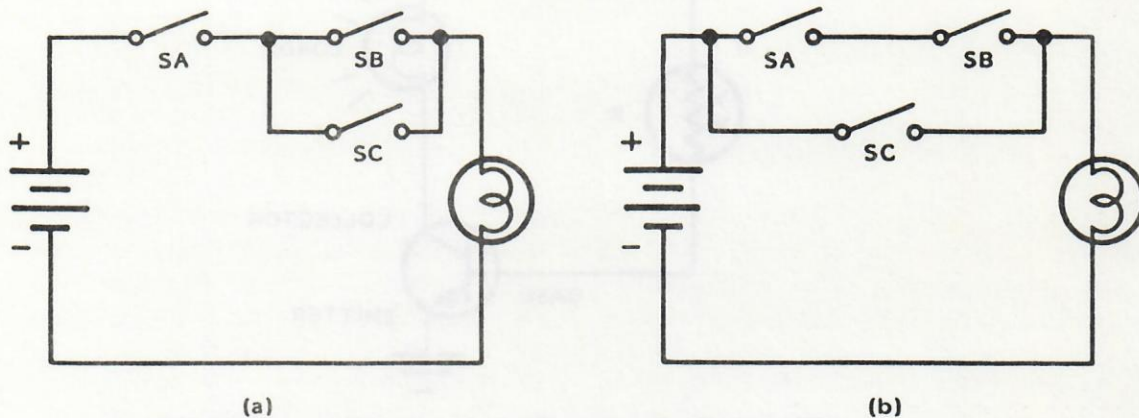


Figure 1 above refers to questions 1 to 5.

1. In Figure 1(a), to light the lamp, switches SB and SC must be closed. _____
2. In Figure 1(a) when switches SA and SC are closed the lamp will light. _____
3. In Figure 1(b), when switches SA and SB are open there is no way to light the lamp. _____
4. In Figure 1(b), when switches SA and SC are closed and SB open the lamp will light. _____
5. The circuit of Figure 1(b) can be defined as an AND-OR. _____
6. In a series circuit there is a single current path for electrons that leave the voltage source but two or more paths for the return to the + terminal. _____
7. A parallel circuit has more than one path for current to follow. _____
8. The current is the same at all points in a series circuit. _____
9. A series circuit can be broken at certain points and current will still flow. _____
10. In a parallel circuit the currents through each branch are always equal in value. _____
11. In a three branch parallel circuit, the total current drain is equal to the sum of the lowest and highest branch currents. _____

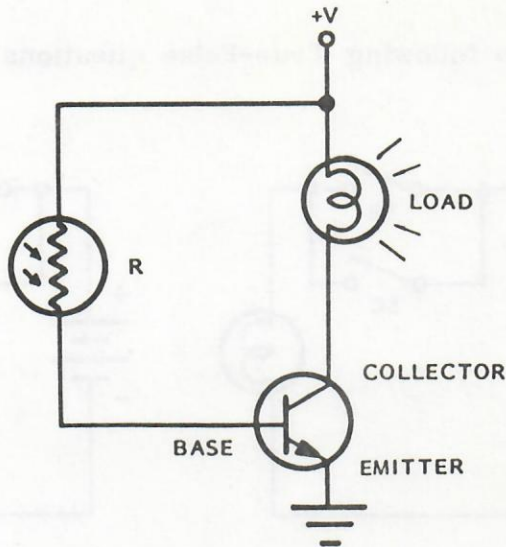


Figure 2 above refers to questions 12 to 14.

12. Component R in Figure 2 varies its resistance with light and is called a Varistor. _____
13. As the light reaching R in Figure 2 increases the lamp glows more brightly. _____
14. As the intensity of light that reaches R in Figure 2 increases, its resistance decreases. _____

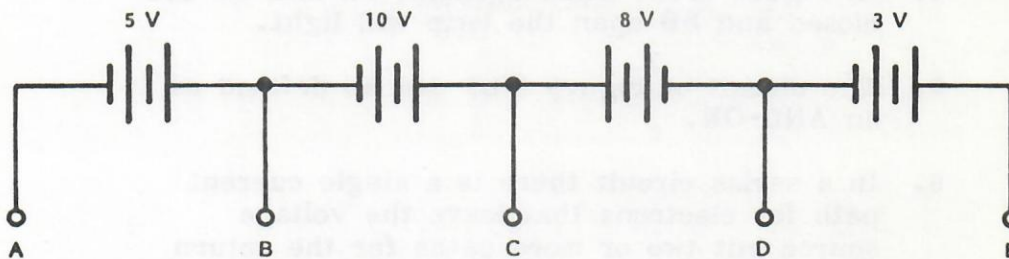


Figure 3 above refers to questions 15 and 16.

15. The voltage that exists between points A and E in Figure 3 is closest to 10 V with A plus and E minus. _____
16. The voltage that exists between points B and D in Figure 3 is 2 volts with B- and D+. _____
17. When measuring voltage with an analog VOM it is proper procedure to start on the high voltage range and lower the range until a mid-scale reading is obtained. _____

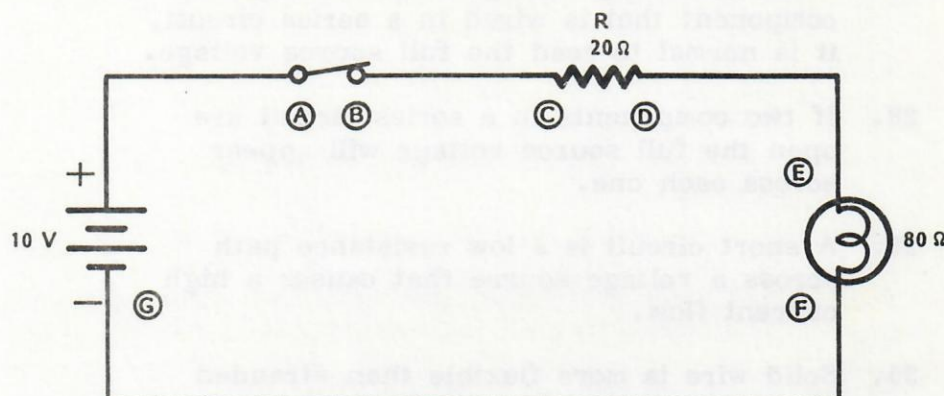


Figure 4 above refers to questions 18 to 20.

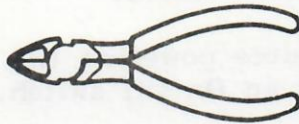
18. A meter reading of 10 volts from C to D in Figure 4 indicates that the resistor, R, is open. _____
19. A meter reading of 10 volts from E to G in Figure 4 is normal. _____
20. A meter reading of 8 volts from E to F in Figure 4 is normal. _____
21. A break in a series circuit causes a high current flow. _____
22. In a parallel circuit the current delivered by the voltage source is equal to the sum of all the branch currents. _____
23. When two identical lamps are placed in series the lamp closest to the negative terminal (current source) will light the brightest. _____
24. A transistor has three terminals, the Base, Collector and Emitter. _____
25. Four flashlight cells connected in series normally produce 6 volts. When two of the cells are reversed the voltage will be 3 volts. _____
26. A digital voltmeter is easier to read but less accurate than an analog voltmeter. _____

27. When measuring voltage across an open circuit component that is wired in a series circuit, it is normal to read the full source voltage. _____
28. If two components in a series circuit are open the full source voltage will appear across each one. _____
29. A short circuit is a low resistance path across a voltage source that causes a high current flow. _____
30. Solid wire is more flexible than stranded wire. _____
31. Solder used for electrical and electronic circuits contains 60% tin and 40% lead. _____
32. A bad wire splice can cause a high resistance connection or an open circuit. _____
33. Electrical splices are made using wire nuts which provide good electrical connection and insulation. _____
34. A 24 gauge wire has a larger diameter than 10 gauge wire. _____
35. When using a wire nut to secure a connection, the two wires being connected should first be twisted. _____

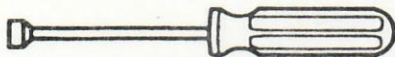
36. Match the tools, components and splices to their descriptions or names listed on the right.



(A)



(B)



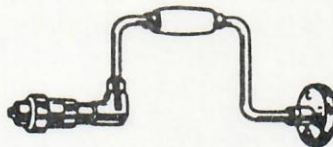
(C)



(D)



(E)



(F)



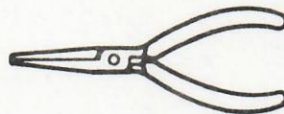
(G)



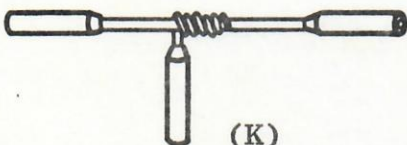
(H)



(I)



(J)



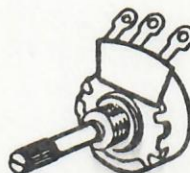
(K)



(L)



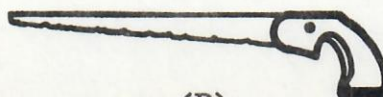
(M)



(N)



(O)



(P)

1. _____ Brace
2. _____ Western Union
3. _____ Phillips
4. _____ Resistor
5. _____ Wire Strippers
6. _____ Keyhole Saw
7. _____ Soldering Iron
8. _____ Lineman Pliers
9. _____ Longnose Pliers
10. _____ Tee
11. _____ Drill Bit
12. _____ Socket Wrench
13. _____ Hack Saw
14. _____ Potentiometer
15. _____ Wire Nut
16. _____ Diagonal Cutter

37. Draw the following circuits.

- a. A lamp, battery, switch and potentiometer in a configuration that allows the lamp to be turned on and off and its intensity varied.
- b. A voltage source powering two lamps in parallel, controlled by an On-Off switch.
- c. A lamp that can be turned On or Off by either of two switches, each located at different places.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E2

1. _____ 8. _____ 15. _____ 22. _____ 29. _____

2. _____ 9. _____ 16. _____ 23. _____ 30. _____

3. _____ 10. _____ 17. _____ 24. _____ 31. _____

4. _____ 11. _____ 18. _____ 25. _____ 32. _____

5. _____ 12. _____ 19. _____ 26. _____ 33. _____

6. _____ 13. _____ 20. _____ 27. _____ 34. _____

7. _____ 14. _____ 21. _____ 28. _____ 35. _____

36.

1. _____ 5. _____ 9. _____ 13. _____

2. _____ 6. _____ 10. _____ 14. _____

3. _____ 7. _____ 11. _____ 15. _____

4. _____ 8. _____ 12. _____ 16. _____

37.

38.

39.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET UNIT TEST 23

1.	_____	2.	_____	3.	_____	4.	_____	5.	_____
6.	_____	7.	_____	8.	_____	9.	_____	10.	_____
11.	_____	12.	_____	13.	_____	14.	_____	15.	_____
16.	_____	17.	_____	18.	_____	19.	_____	20.	_____
21.	_____	22.	_____	23.	_____	24.	_____	25.	_____
26.	_____	27.	_____	28.	_____	29.	_____	30.	_____
31.	_____	32.	_____	33.	_____	34.	_____	35.	_____
36.	_____	37.	_____	38.	_____	39.	_____	40.	_____

20

1.	_____	2.	_____	3.	_____	4.	_____	5.	_____
6.	_____	7.	_____	8.	_____	9.	_____	10.	_____
11.	_____	12.	_____	13.	_____	14.	_____	15.	_____
16.	_____	17.	_____	18.	_____	19.	_____	20.	_____

20

20

20

UNIT TEST - BOOK E3

DC OHM'S LAW

UNIT TEST - BOOK 13

DC OHIO LAB

Answer the following multiple choice questions.

1. The correct forms of Ohm's Law are:
 - a. $E=RI$; $I=E/R$; $R=E/I$
 - b. $E=IR$; $I=R/E$; $R=I/E$
 - c. $E=IR$; $I=ER$; $R=E/I$
 - d. $E=I/R$; $I=E/R$; $R=E/I$
2. Twenty five volts is applied to a 5 K resistance. The current flow will be closest to:
 - a. 0.05 A.
 - b. 200 mA.
 - c. 0.005 A.
 - d. none of the above.
3. A resistance of 4.7 K has a current of 10 mA flowing through it. The voltage drop across the resistor is:
 - a. 470 V.
 - b. 47 V.
 - c. 0.002 V.
 - d. none of the above.
4. A circuit has a current flow of 35 mA when 14 volts is applied. This indicates a circuit resistance closest to
 - a. 400 ohms.
 - b. 250 ohms.
 - c. 490 ohms.
 - d. none of the above.

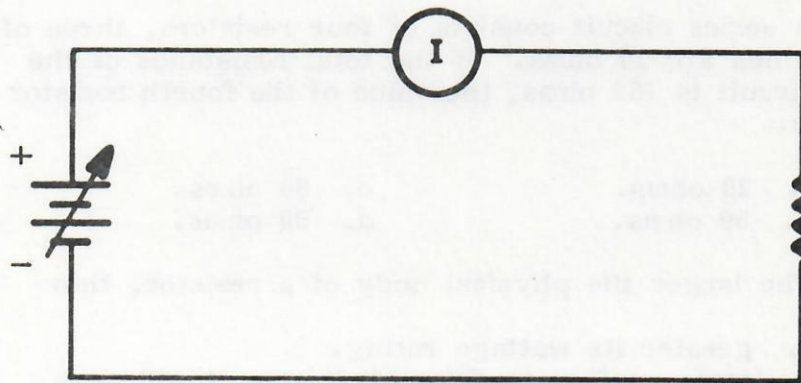


Figure 1 above refers to questions 5 to 7.

5. In Figure 1, the Dependent Variable is the:
 - a. voltage.
 - b. current.
 - c. resistance.
 - d. technician's choice.
6. The Volt-Ampere characteristic for Figure 1 is:
 - a. linear.
 - b. non-linear.
 - c. linear only at the low end.
 - d. linear only at the high end.

7. In Figure 1, the Independent Variable is the:
- a. voltage.
 - b. current.
 - c. resistance.
 - d. technician's choice.
8. A circuit or component with a linear Volt-Ampere characteristic plot would have a:
- a. curved line plot when graphed.
 - b. straight line plot when graphed.
 - c. lower resistance at the low voltage end.
 - d. higher resistance at the low voltage end.
9. Three resistors, 1K, 4.7 K and 5.6 K are connected in series across a 100 V source. The circuit current flow is:
- a. 8.85 mA.
 - b. 88.5 mA.
 - c. 0.0885 A.
 - d. insufficient data.
10. A series resistive circuit is formed with three equal value resistors. When connected across a 30 V source, 0.01 A flows. The value of a single resistor is:
- a. 3 K.
 - b. 10 ohms.
 - c. 1 K.
 - d. 300 ohms.
11. A series circuit consists of four resistors, three of which are 20 ohms. If the total resistance of the circuit is 150 ohms, the value of the fourth resistor is:
- a. 20 ohms.
 - b. 50 ohms.
 - c. 80 ohms.
 - d. 90 ohms.
12. The larger the physical body of a resistor, the:
- a. greater its wattage rating.
 - b. more surface to air contact area it will have.
 - c. more heat it can radiate into the surrounding air:
 - d. all of the above.
13. When only the current through a resistor and the voltage drop across it are known the wattage dissipated should be calculated from:
- a. $I \cdot R$
 - b. $I^2 \cdot E$
 - c. $I \cdot E$
 - d. all of the above.

14. A resistor dissipates 0.003 watts. This is the equivalent of:
- a. 3 milliwatts.
 - b. 300 microwatts.
 - c. 300 watts.
 - d. 0.0003 kilowatts.

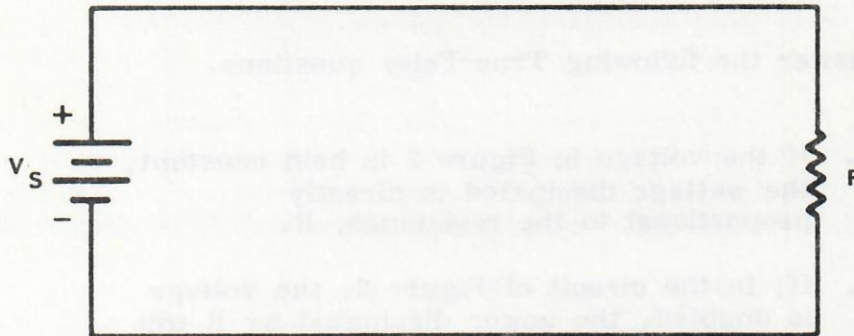


Figure 2 above refers to questions 15 to 19.

15. Given that $V_S = 30\text{ V}$ and that $I = 15\text{ mA}$ in Figure 2, the total power delivered by the source is:
- a. 450 W.
 - b. 450 mW.
 - c. 2000 mW.
 - d. 450 μW .
16. In Figure 2, given that R equals 30 K and V_S equals 30 V, the power dissipated by R is:
- a. 0.03 W
 - b. 30 W.
 - c. 270 milliwatts.
 - d. none of the above.
17. In the circuit of Figure 2, the voltage is held constant and R is decreased. The power dissipated by R :
- a. decreases.
 - b. increases.
 - c. holds constant.
 - d. none of the above.
18. If in Figure 2, the input voltage is doubled, the power dissipated by R will increase by a factor of:
- a. 1.
 - b. 2.
 - c. 4.
 - d. 6.
19. In the circuit of Figure 2, when R is 5K and draws 20 mA the wattage dissipated is:
- a. 20 W.
 - b. 10 W.
 - c. 2 W.
 - d. insufficient data.

20. Three resistors are connected in series across a source that delivers 30 watts. One resistor dissipates 8 watts, the second resistor dissipates 11 watts. The third resistor must dissipate:
- a. 19 watts.
 - b. 3 watts.
 - c. 1.375 watts.
 - d. 11 watts.

Answer the following True-False questions.

21. If the voltage in Figure 2 is held constant, the wattage dissipated is directly proportional to the resistance, R. _____
22. If, in the circuit of Figure 2, the voltage is doubled, the power dissipated by R will also double. _____
23. If, in Figure 2, the resistor R is 100 K, the voltage required to dissipate one watt is approximately 316 V. _____
24. Two resistors, each rated 1 K at 2 watts, are placed in series. The series pair are equal to 2 K at 4 W. _____
25. A law of series circuits states that the total resistance is equal to the sum of the individual resistances in the circuit. _____
26. A law of series circuits states that the current flow is highest closest to the negative terminal of the power source where the electrons start from. _____
27. The total series resistance for a 1,000 ohm, 3.3 K and 4.7 K resistance is 1.8 K. _____
28. The EIA color code cannot be used for resistance values below 10 ohms. _____
29. A resistor of the carbon composition type can develop electrical noise when a current flows through it. _____
30. Deposited film resistors are electrically quieter than carbon composition types. _____

Perform the following computations.

31. Convert the following numbers to Engineering Notation form and round off to three significant figures.

- | | |
|-----------------|------------------------|
| a. 0.000573 | d. 1400×10^7 |
| b. 897,000 | e. 0.257×10^4 |
| c. 0.0000000897 | f. 5,763,970 |

32. Perform the following division problems using scientific notation. Express the answers in numbers from 1 to 10 and round off to three significant figures. Show your work in the space provided on the answer sheet.

- a. $2.7 \times 10^4 \div 2.4 \times 10^3$
b. $820,000 \div 1.2 \times 10^2$
c. $27,500 \div 1.7 \times 10^{-3}$
d. $55 \times 10^{-3} \div 12 \times 10^{-6}$
e. $227,585 \div 5720$

33. Solve the following problems using scientific notation. Express the answers in scientific notation form rounded off to 3 significant figures. Show your work in the space provided in the answer sheet.

- a. $(53 \times 10^4)^2$
b. $(10^7)^2$
c. $\sqrt{625 \times 10^4}$
d. $\sqrt{1960 \times 10^7}$
e. $\sqrt{484 \times 10^{-6}}$

34. Write the significant digit next to each color.

- | | | | |
|-----------|-------|-----------|-------|
| a. Violet | _____ | f. Brown | _____ |
| b. Red | _____ | g. White | _____ |
| c. Grey | _____ | h. Green | _____ |
| d. Black | _____ | i. Blue | _____ |
| e. Orange | _____ | j. Yellow | _____ |

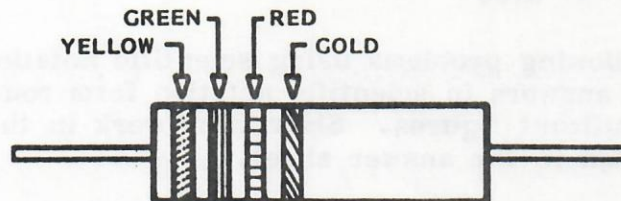
35. List the number of zeroes to add if each of the colors below were the third band.

- | | | | |
|-----------|-------|-----------|-------|
| a. Violet | _____ | f. Yellow | _____ |
| b. Red | _____ | g. White | _____ |
| c. Grey | _____ | h. Blue | _____ |
| d. Black | _____ | i. Green | _____ |
| e. Orange | _____ | j. Brown | _____ |

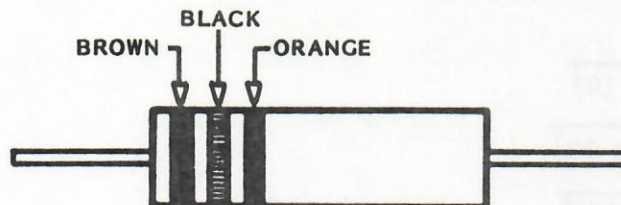
36. List the tolerance rating for each of the colors listed below.

- | | |
|-------------|-------|
| a. Silver | _____ |
| b. No Color | _____ |
| c. Gold | _____ |

37. Determine the value and tolerance of each resistor shown below.



a. _____



b. _____

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E3

(Multiple Choice)

1. _____ 5. _____ 9. _____ 13. _____ 17. _____

2. _____ 6. _____ 10. _____ 14. _____ 18. _____

3. _____ 7. _____ 11. _____ 15. _____ 19. _____

4. _____ 8. _____ 12. _____ 16. _____ 20. _____

(True-False)

21. _____ 23. _____ 25. _____ 27. _____ 29. _____

22. _____ 24. _____ 26. _____ 28. _____ 30. _____

(Computations)

31.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E3

32.

a.

b.

c.

d.

e.

33.

a.

b.

c.

d.

e.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E3

34.

a. _____

f. _____

b. _____

g. _____

c. _____

h. _____

d. _____

i. _____

e. _____

j. _____

35.

a. _____

f. _____

b. _____

g. _____

c. _____

h. _____

d. _____

i. _____

e. _____

j. _____

36.

a. _____

b. _____

c. _____

37.

a. _____

b. _____

DATE

CLASS

NAME

ANSWER SHEET - UNIT TEST 23

1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____
9.	_____	_____	_____
10.	_____	_____	_____
11.	_____	_____	_____
12.	_____	_____	_____
13.	_____	_____	_____
14.	_____	_____	_____
15.	_____	_____	_____
16.	_____	_____	_____
17.	_____	_____	_____
18.	_____	_____	_____
19.	_____	_____	_____
20.	_____	_____	_____
21.	_____	_____	_____
22.	_____	_____	_____
23.	_____	_____	_____
24.	_____	_____	_____
25.	_____	_____	_____
26.	_____	_____	_____
27.	_____	_____	_____
28.	_____	_____	_____
29.	_____	_____	_____
30.	_____	_____	_____
31.	_____	_____	_____
32.	_____	_____	_____
33.	_____	_____	_____
34.	_____	_____	_____
35.	_____	_____	_____
36.	_____	_____	_____
37.	_____	_____	_____
38.	_____	_____	_____
39.	_____	_____	_____
40.	_____	_____	_____
41.	_____	_____	_____
42.	_____	_____	_____
43.	_____	_____	_____
44.	_____	_____	_____
45.	_____	_____	_____
46.	_____	_____	_____
47.	_____	_____	_____
48.	_____	_____	_____
49.	_____	_____	_____
50.	_____	_____	_____
51.	_____	_____	_____
52.	_____	_____	_____
53.	_____	_____	_____
54.	_____	_____	_____
55.	_____	_____	_____
56.	_____	_____	_____
57.	_____	_____	_____
58.	_____	_____	_____
59.	_____	_____	_____
60.	_____	_____	_____
61.	_____	_____	_____
62.	_____	_____	_____
63.	_____	_____	_____
64.	_____	_____	_____
65.	_____	_____	_____
66.	_____	_____	_____
67.	_____	_____	_____
68.	_____	_____	_____
69.	_____	_____	_____
70.	_____	_____	_____
71.	_____	_____	_____
72.	_____	_____	_____
73.	_____	_____	_____
74.	_____	_____	_____
75.	_____	_____	_____
76.	_____	_____	_____
77.	_____	_____	_____
78.	_____	_____	_____
79.	_____	_____	_____
80.	_____	_____	_____
81.	_____	_____	_____
82.	_____	_____	_____
83.	_____	_____	_____
84.	_____	_____	_____
85.	_____	_____	_____
86.	_____	_____	_____
87.	_____	_____	_____
88.	_____	_____	_____
89.	_____	_____	_____
90.	_____	_____	_____
91.	_____	_____	_____
92.	_____	_____	_____
93.	_____	_____	_____
94.	_____	_____	_____
95.	_____	_____	_____
96.	_____	_____	_____
97.	_____	_____	_____
98.	_____	_____	_____
99.	_____	_____	_____
100.	_____	_____	_____

UNIT TEST - BOOK E4

DC CIRCUITS AND LAWS

UNIT TEST - Page 14

DE COURTES AND LANE

Answer the following multiple choice questions.

1. The use of a milliammeter to measure current is avoided in the field because:
 - a. it is possible to burn out components.
 - b. the milliammeter always burns out when used to measure current.
 - c. the reading obtained is rarely accurate or dependable.
 - d. it requires cutting a wire or printed circuit foil.
2. The current flow in a series circuit can be computed if you know only the:
 - a. applied voltage.
 - b. resistance of one of the series components.
 - c. resistance and voltage across one of the series components.
 - d. voltage across one of the series components.
3. Given that a component has a 5 volt drop across it and a 1500 ohm resistance, the current flow through it is closest to:

a. 0.003 A.	c. 3000 μ A.
b. 3 mA.	d. all of the above.

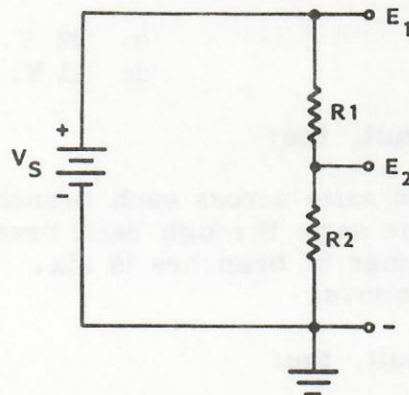


Figure 1 above refers to questions 4 and 5.

4. For the circuit of Figure 1, given that $V_S = 50$ V, $R1 = 4.7$ K and $R2 = 22$ K, voltage E_2 to ground will be closest to:

a. 8.8 V.	c. 41 V.
b. 33 V.	d. 50 V.
5. For the circuit of Figure 1, given that $V_S = 24$ V, $R1 = 2.2$ K and $R2 = 10$ K, the output voltage E_2 will be closest to:

a. 4.3 V.	c. 19.7 V.
b. 15 V.	d. 24 V.

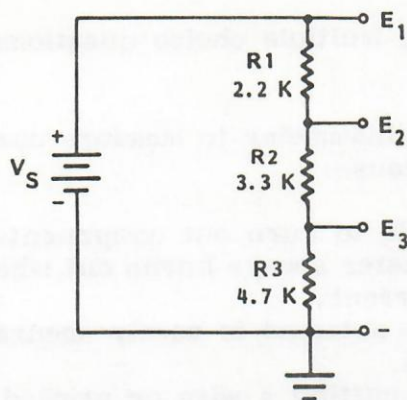


Figure 2 above refers to questions 6 to 8.

6. For the circuit of Figure 2, given that V_S is 30 volts, voltage E_3 to ground is:
 - a. 13.8 V.
 - b. 16.5 V.
 - c. 24 V.
 - d. 30 V.
7. For the circuit of Figure 2, given that V_S is 50 volts the voltage from E_2 to ground will be closest to:
 - a. 50 V.
 - b. 39 V.
 - c. 22 V.
 - d. 11 V.
8. For the circuit of Figure 2, given that V_S is 50 volts the voltage drop across R_1 is closest to:
 - a. 50 V.
 - b. 39 V.
 - c. 22 V.
 - d. 11 V.
9. In a parallel circuit, the:
 - a. voltage is the same across each branch.
 - b. current is the same through each branch.
 - c. maximum number of branches is six.
 - d. none of the above.
10. In a parallel circuit, the:
 - a. equivalent resistance is never less than the lowest resistance in the network.
 - b. total current is equal to the sum of the branch currents.
 - c. total current is equal to the sum of the branch currents divided by the number of branches.
 - d. none of the above.

11. In a parallel circuit that has equal value resistance branches, R_{eq} may be determined from:

a. $R_{eq} = R/N$.
b. $R_{eq} = I_T/E_S$.
c. $R_{eq} = 1/R_1 + 1/R_2 + 1/R_N$.
d. all of the above.

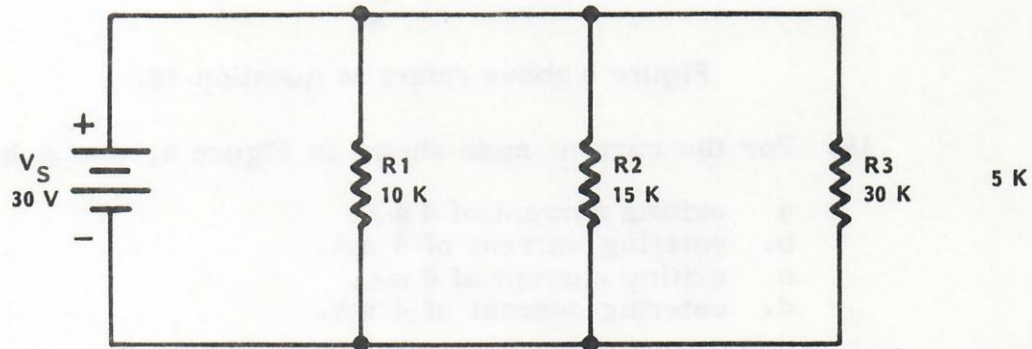


Figure 3 above refers to questions 12 to 15.

12. In the circuit of Figure 3, the voltage drop across each resistance is:

a. different.
b. 10 V.
c. 30 V.
d. none of the above.

13. In the circuit of Figure 3, the currents flowing through R_1 , R_2 and R_3 are:

a. equal.
b. directly proportional to the branch resistances.
c. inversely proportional to V_S .
d. respectively, 3 mA, 2 mA, 1 mA.

14. In the circuit of Figure 3, the equivalent resistance is equal to:

a. the lowest branch resistance, 10 K.
b. exactly 55 K.
c. exactly 5 K.
d. an average of the 3 resistances, 18.3 K.

15. If, in Figure 3, R_3 is removed from the circuit, leaving only R_1 and R_2 , the:

a. source voltage will remain unchanged.
b. total current drain will decrease.
c. both a and b.
d. neither a or b.

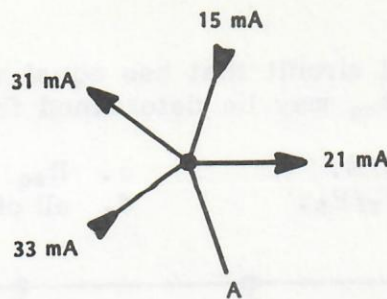


Figure 4 above refers to question 16.

16. For the current node shown in Figure 4, line A has an:
- a. exiting current of 4 mA.
 - b. entering current of 6 mA.
 - c. exiting current of 6 mA.
 - d. entering current of 4 mA.

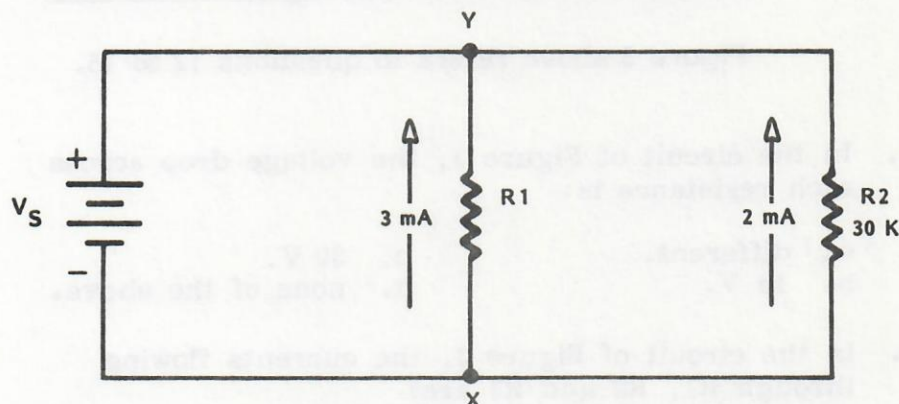


Figure 5 above refers to questions 17 to 21.

17. For the circuit shown in Figure 5, the current entering node X is:
- a. 3 mA.
 - b. 5 mA.
 - c. 2 mA.
 - d. none of the above.
18. For the circuit shown in Figure 5, the current leaving node X is:
- a. 3 mA.
 - b. 5 mA.
 - c. 2 mA.
 - d. none of the above.
19. For the circuit of Figure 5, the source voltage is:
- a. 15 V.
 - b. 30 V.
 - c. 60 V.
 - d. 150 V.
20. In the circuit of Figure 5, the value of R1 is:
- a. 20 K.
 - b. 10 K.
 - c. 5 K.
 - d. none of the above.

Answer the following True-False questions.

26. Kirchhoff's voltage law states that the sum of the voltage drops in a series circuit are equal to the source. _____
27. Kirchhoff's voltage law states that the algebraic sum of all the voltages and source in the loop equal $2V_S$. _____
28. A 30 volt source is connected to a series circuit. The sum of all the voltage drops in the circuit will equal 30 volts. _____
29. Three equal value resistors are connected in series across a 9 V battery. Each resistor will have a 3 volt drop across it. _____
30. A series circuit containing three resistors is connected to a 30 volt source. One voltage drop is 15 V, the other 10 V. The third is 5 V. _____

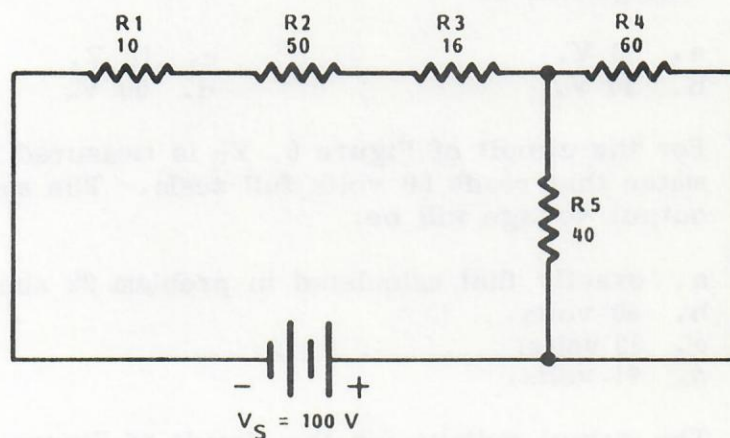


Figure 7 above refers to questions 31 to 35.

31. The circuit of Figure 7 is a series parallel network. _____
32. In the circuit of Figure 7 the total current will flow through R1, R2, R3, and R5. _____
33. The first step necessary to find R_{eq} for Figure 7 is to add all five resistance values. _____
34. The equivalent resistance of Figure 7 is $176\ \Omega$. _____
35. The total current flow, I_T , in Figure 7 is 1 A. _____

36. A D'Arsonval meter operates on the principle of the interaction of two magnetic fields. _____
37. A D'Arsonval meter has a moving coil that acts as an electromagnet. _____
38. The pointer of a D'Arsonval meter is attached to the outer edge of the hair spring in the movement. _____
39. The resistance of a meter movement consists of the wire resistance of the moving coil. _____
40. A current meter can be used as an ammeter when wired correctly but not usually as a voltmeter. _____
41. A shunt may be used to increase the current range of a milliammeter. _____
42. A resistor placed in series with a current meter allows the meter to be used as a voltmeter. _____
43. The series resistor used for a voltmeter is called a "shunt resistor." _____
44. A 0 to 100 μA meter is to be used as a 0 to 20 voltmeter. The required multiplier resistor is 100 K ohms. _____
45. A 0 to 100 μA meter, when used as a voltmeter has a sensitivity of 10 $\text{K}\Omega/\text{V}$. _____
46. A 0-1 mA meter, when used as a voltmeter will have a better sensitivity figure than the 0-100 μA meter. _____
47. The resistance of a meter movement should be subtracted from the multiplier resistance at low and medium voltage ranges but not necessarily for high ranges. _____
48. If a 0-1 mA meter must be used to measure a current of 5 mA, 4 mA must flow through the shunt. _____
49. A shunt is a resistor placed in series with a meter to increase its current range. _____
50. A shunt can be used to increase or decrease the current range of a D'Arsonval meter. _____
51. If the resistance of a shunt wired across a meter is exactly equal to the resistance of the meter, the current range will double. _____

52. A microammeter has a movement resistance of 1 K and a full-scale deflection of $100\ \mu\text{A}$. A 200 ohm shunt will increase the current range to approximately 0.5 mA.

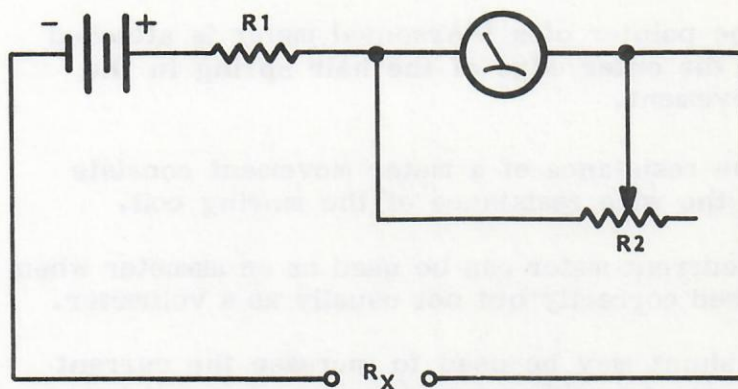
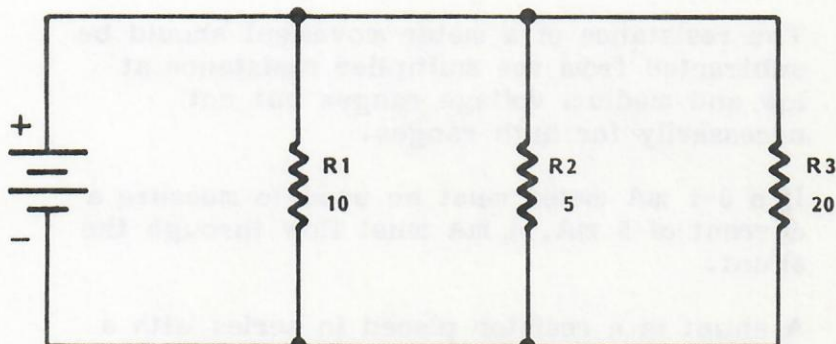


Figure 8 above refers to questions 53 to 55.

53. The function of R_1 in Figure 8 is to determine the ohmmeter resistance range.
54. When R_1 in Figure 8 is increased in value by 10 times, the ohmmeter resistance range is increased by the same factor.
55. The function of R_2 in Figure 8 is to zero adjust the ohmmeter when the R_X terminals are open.

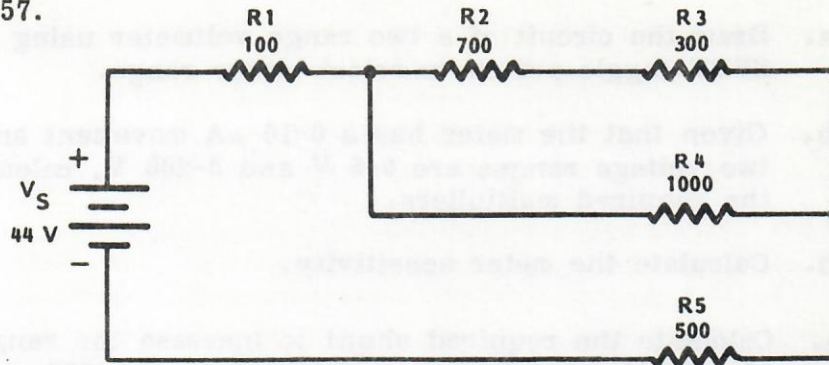
Solve the following problems showing all work.

56.



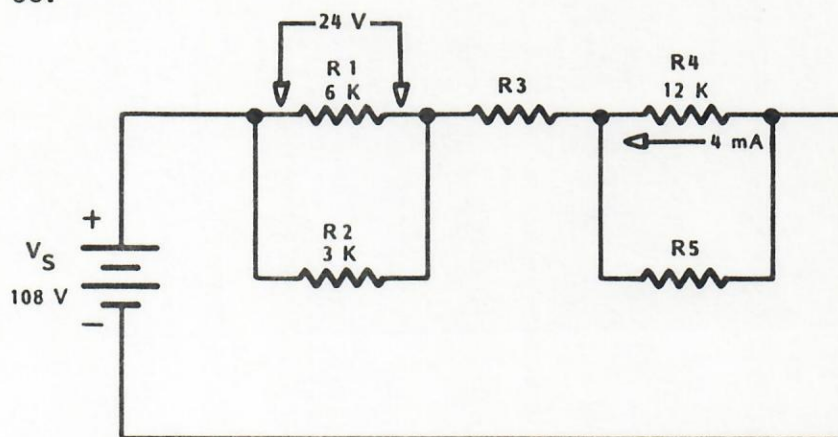
Solve for R_{eq} .

57.



- Solve for R_{eq} .
- Determine I_T .
- Calculate the voltage drops across R_1 and R_5 .

58.



- Calculate I_T .
- Determine the current flow through R_5 .
- Calculate the value of R_5 .
- Calculate the voltage drop across R_3 .
- Calculate the equivalent resistance of the network.

59. a. Draw the circuit of a two range voltmeter using SPDT toggle switch to select either range.
- b. Given that the meter has a $0-10\ \mu\text{A}$ movement and the two voltage ranges are $0-5\ \text{V}$ and $0-200\ \text{V}$, calculate the required multipliers.
- c. Calculate the meter sensitivity.
60. a. Calculate the required shunt to increase the range of a $0-500\ \mu\text{A}$ meter movement that has a $1500\ \text{ohm}$ resistance to a new full-scale of $100\ \text{mA}$. Select the most practical formula and show all work.
- b. Calculate the new full scale current range of a $0-50\ \mu\text{A}$ meter with an internal resistance of $4\ \text{K}$ and a shunt resistance of $10\ \text{ohms}$. Show all work.



NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E4

(Multiple Choice)

- | | | | | |
|----------|-----------|-----------|-----------|-----------|
| 1. _____ | 6. _____ | 11. _____ | 16. _____ | 21. _____ |
| 2. _____ | 7. _____ | 12. _____ | 17. _____ | 22. _____ |
| 3. _____ | 8. _____ | 13. _____ | 18. _____ | 23. _____ |
| 4. _____ | 9. _____ | 14. _____ | 19. _____ | 24. _____ |
| 5. _____ | 10. _____ | 15. _____ | 20. _____ | 25. _____ |

(True-False)

- | | | | | |
|-----------|-----------|-----------|-----------|-----------|
| 26. _____ | 32. _____ | 38. _____ | 44. _____ | 50. _____ |
| 27. _____ | 33. _____ | 39. _____ | 45. _____ | 51. _____ |
| 28. _____ | 34. _____ | 40. _____ | 46. _____ | 52. _____ |
| 29. _____ | 35. _____ | 41. _____ | 47. _____ | 53. _____ |
| 30. _____ | 36. _____ | 42. _____ | 48. _____ | 54. _____ |
| 31. _____ | 37. _____ | 43. _____ | 49. _____ | 55. _____ |

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E4

(Problem Solving)

56.

57. a.

b.

c.

58. a.

b.

c.

d.

e.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E4

59. a.

b.

c.

60. a.

b.

NAME

CLASS

DATE

ANSWER SHEET - UNIT TEST 1A

UNIT TEST - BOOK E5

DC CIRCUITS AND THEOREMS

UNIT TEST - BOOK 12

DC CIRCUITS AND THERMISTORS

Answer the following True-False questions.

1. Maximum voltage is delivered to a load by a power source when the load resistance is lower than the internal resistance. _____
2. Maximum power is delivered to a load when the load resistance is equal to the internal resistance of the source. _____
3. Maximum current is delivered to a load by a power source when the load resistance is higher than the internal source resistance. _____
4. When a 0.005 ohm load resistance is placed across a 12 V car battery with a 0.005 ohm internal resistance, maximum power will be delivered but the excessive current flow will damage the battery and the circuit. _____
5. When the internal source resistance R_i equals R_L , and the load resistance is then increased in value, the voltage output will increase and the power output will decrease. _____

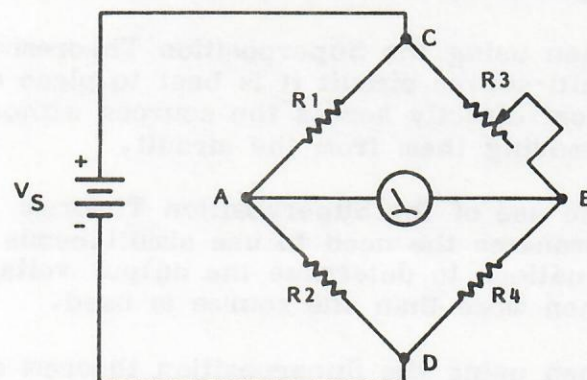


Figure 1 refers to questions 6 to 12.

6. When the Wheatstone Bridge circuit shown in Figure 1 is balanced, voltage A - D will always be one half of V_S . _____
7. For the circuit of Figure 1, given that R_1 equals R_3 and R_2 equals R_4 , the meter will read zero volts. _____

8. For Figure 1, given the resistance values listed below, the bridge will be nulled.

$R_1 = 10 \text{ K}$; $R_2 = 22 \text{ K}$; $R_3 = 7 \text{ K}$; $R_4 = 15.4 \text{ K}$

9. When, in Figure 1, the ratio of R_1 to R_2 equals the ratio of R_4 to R_3 the bridge will balance.
10. In Figure 1, when the voltage from A to D is +7.5 V and the voltage from B to D equals -7.5 V, the bridge is balanced.
11. When, in Figure 1, R_1 equals R_2 , and it is desired to increase the resistance range of the bridge by a factor of 100, it is necessary to increase R_2 by 100 times.
12. For the circuit of Figure 1, given that R_1 and R_2 are 100 K each and R_3 is 1 megohm, the maximum resistance that can be measured is 1 megohm.
13. To properly apply the Superposition Theorem to a complex circuit with two voltage sources, each of the two sources must be replaced by a short circuit, in turn.
14. When using the Superposition Theorem in a multi-source circuit it is best to place a short directly across the sources without removing them from the circuit.
15. The use of the Superposition Theorem eliminates the need to use simultaneous equations to determine the output voltage when more than one source is used.
16. When using the Superposition theorem on a network that has three voltage sources, the output voltage for each source is determined individually and then all are added algebraically to find V_O for all the sources applied at one time.
17. Thevenin's Theorem is used to develop the simplest possible equivalent circuit for a complex network. The Thevenin equivalent consists of only one voltage source, V_{Th} , and a series resistance, R_{Th} .

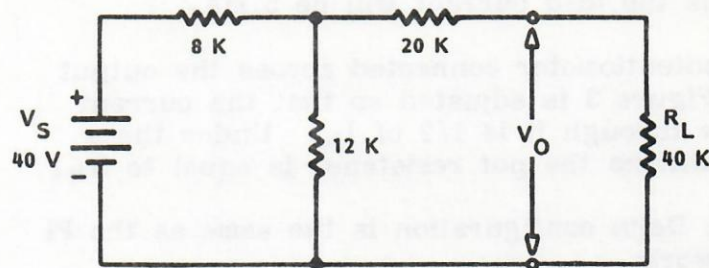


Figure 2 refers to questions 18 to 22.

18. To determine V_{Th} for the circuit in Figure 2 it is necessary to remove V_S and replace it with a short circuit. _____
19. The value of R_{Th} for Figure 2 is 24.8 K. _____
20. The value of V_{Th} for Figure 2 is 24 V unloaded. _____
21. The loaded output voltage for Figure 2 is less than the Thevenin voltage. _____
22. A resistor, R_L , connected across the output of Figure 2 drops V_O to one half of V_{Th} . You can conclude that under these condition R_L is equal to V_{Th} . _____
23. Norton's Theorem is used to develop the simplest possible equivalent circuit for a complex network that results in a current source, I_N , in parallel with a single resistance, R_N . _____

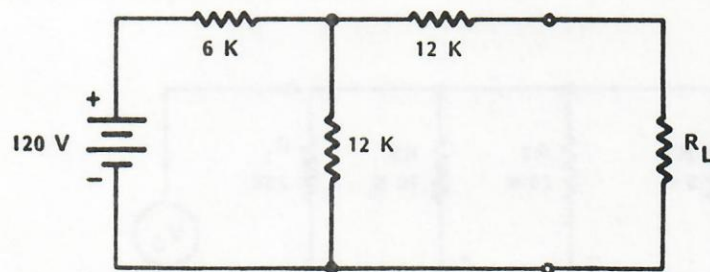


Figure 3 refers to questions 24 to 28.

24. For the circuit of Figure 3, the Norton current, I_N , is equal to 5 mA. _____
25. For the circuit of Figure 3, the Norton resistance, R_N , equals 18 K. _____
26. If I_N is to be measured in Figure 3, a milliammeter may be placed in series with R_L . _____

27. For the circuit of Figure 3, given an R_L of 5 ohms the load current will be 5 mA. _____
28. A potentiometer connected across the output of Figure 3 is adjusted so that the current flow through it is $1/2$ of I_N . Under these conditions the pot resistance is equal to R_N . _____
29. The Delta configuration is the same as the Pi network. _____
30. A Wye configuration is the equivalent of the T network. _____

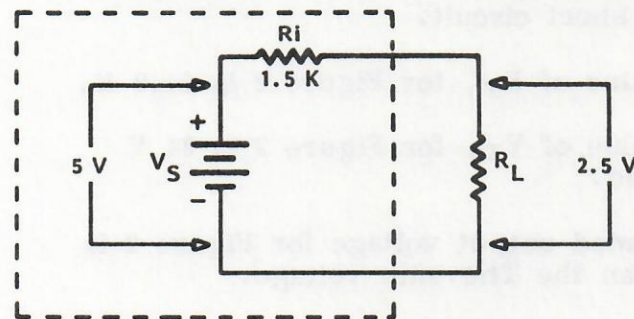


Figure 4.

31. Determine the following for Figure 4:
- The value of R_L .
 - The power that will be dissipated by R_L .
 - The maximum power that R_L can dissipate.

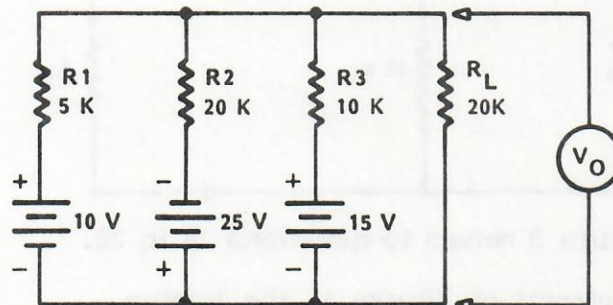


Figure 5.

32. Calculate V_O for the circuit of Figure 5 using the Superposition Theorem.

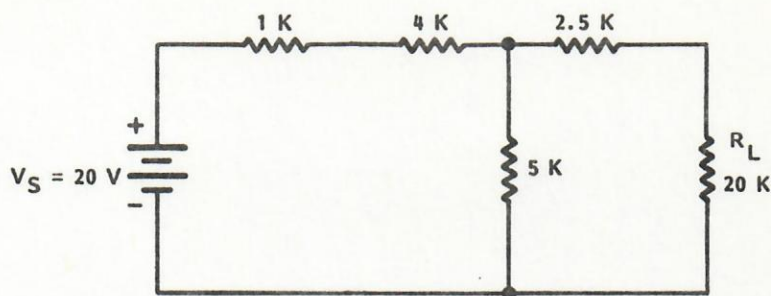


Figure 6.

33. Determine the following for Figure 6.
- V_{Th} .
 - R_{Th} .
 - V_O loaded.
34. Draw the form used to show the Norton's equivalent of a complex circuit.
35. Draw the form used to show the Thevenin's equivalent of a complex circuit.



Figure 1

2. Determine the following for Figure 1.

- a. V_{R1}
- b. V_{R2}
- c. V_{R3}

3. Draw the loop and show the KVL equation at a single loop.

4. Draw the loop and show the KVL equation at a single loop.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E5

1. _____ 7. _____ 13. _____ 19. _____ 25. _____

2. _____ 8. _____ 14. _____ 20. _____ 26. _____

3. _____ 9. _____ 15. _____ 21. _____ 27. _____

4. _____ 10. _____ 16. _____ 22. _____ 28. _____

5. _____ 11. _____ 17. _____ 23. _____ 29. _____

6. _____ 12. _____ 18. _____ 24. _____ 30. _____

31.

a. R_L

b. P_{RL}

c. Maximum P_{RL}

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E5

32. V_O

_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

33.

a. V_{Th}

b. R_{Th}

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E5

c. V_O Loaded

34.

35.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST 6

of 10 pages

Ed-Lab 651

ANSWER KEY

UNIT TESTS

MODULE 1

UNITS E1 TO E5

1. Answer Key, Unit Test E1
2. Answer Key, Unit Test E2
3. Answer Key, Unit Test E3
4. Answer Key, Unit Test E4
5. Answer Key, Unit Test E5

Ed-Lab 651

WAGNER KEY

UNIT TESTS

MODULE 1

UNIT 10 TO 12

1.	Answer Key, Unit Test 10
2.	Answer Key, Unit Test 11
3.	Answer Key, Unit Test 12
4.	Answer Key, Unit Test 13
5.	Answer Key, Unit Test 14

NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E1

1. F 7. F 13. T 19. T 25. F

2. T 8. T 14. F 20. F 26. F

3. T 9. T 15. F 21. F 27. T

4. F 10. F 16. T 22. T 28. T

5. T 11. F 17. T 23. F 29. F

6. T 12. T 18. F 24. T 30. F

31.

1. G 5. K 9. C 32. 1. G 6. J

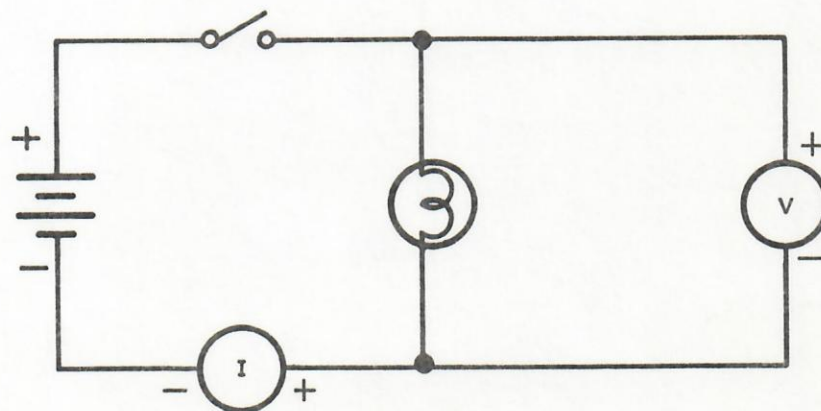
2. I 6. B 10. A 2. I 7. F

3. J 7. L 11. E 3. B 8. C

4. D 8. H 12. F 4. E 9. H

5. A 10. D

33.



ANSWER SHEET - UNIT TEST II

1. <u>10.0</u>	2. <u>10.0</u>	3. <u>10.0</u>	4. <u>10.0</u>	5. <u>10.0</u>
6. <u>10.0</u>	7. <u>10.0</u>	8. <u>10.0</u>	9. <u>10.0</u>	10. <u>10.0</u>
11. <u>10.0</u>	12. <u>10.0</u>	13. <u>10.0</u>	14. <u>10.0</u>	15. <u>10.0</u>
16. <u>10.0</u>	17. <u>10.0</u>	18. <u>10.0</u>	19. <u>10.0</u>	20. <u>10.0</u>
21. <u>10.0</u>	22. <u>10.0</u>	23. <u>10.0</u>	24. <u>10.0</u>	25. <u>10.0</u>
26. <u>10.0</u>	27. <u>10.0</u>	28. <u>10.0</u>	29. <u>10.0</u>	30. <u>10.0</u>
31. <u>10.0</u>	32. <u>10.0</u>	33. <u>10.0</u>	34. <u>10.0</u>	35. <u>10.0</u>
36. <u>10.0</u>	37. <u>10.0</u>	38. <u>10.0</u>	39. <u>10.0</u>	40. <u>10.0</u>
41. <u>10.0</u>	42. <u>10.0</u>	43. <u>10.0</u>	44. <u>10.0</u>	45. <u>10.0</u>
46. <u>10.0</u>	47. <u>10.0</u>	48. <u>10.0</u>	49. <u>10.0</u>	50. <u>10.0</u>



NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

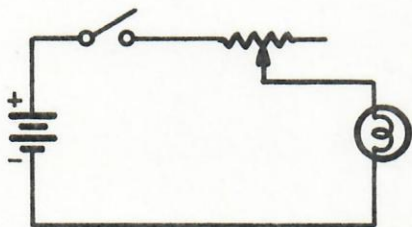
ANSWER SHEET - UNIT TEST E2

- | | | | | |
|-------------|--------------|--------------|--------------|--------------|
| 1. <u>F</u> | 8. <u>T</u> | 15. <u>F</u> | 22. <u>T</u> | 29. <u>T</u> |
| 2. <u>T</u> | 9. <u>F</u> | 16. <u>T</u> | 23. <u>F</u> | 30. <u>F</u> |
| 3. <u>F</u> | 10. <u>F</u> | 17. <u>T</u> | 24. <u>T</u> | 31. <u>T</u> |
| 4. <u>T</u> | 11. <u>F</u> | 18. <u>T</u> | 25. <u>F</u> | 32. <u>T</u> |
| 5. <u>T</u> | 12. <u>F</u> | 19. <u>F</u> | 26. <u>F</u> | 33. <u>T</u> |
| 6. <u>F</u> | 13. <u>T</u> | 20. <u>T</u> | 27. <u>T</u> | 34. <u>F</u> |
| 7. <u>T</u> | 14. <u>T</u> | 21. <u>F</u> | 28. <u>F</u> | 35. <u>F</u> |

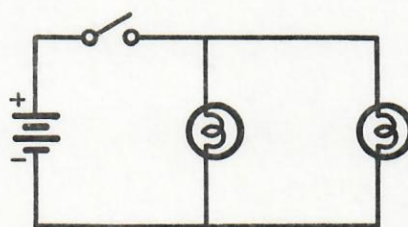
36.

- | | | | |
|-------------|-------------|--------------|--------------|
| 1. <u>F</u> | 5. <u>G</u> | 9. <u>J</u> | 13. <u>I</u> |
| 2. <u>L</u> | 6. <u>P</u> | 10. <u>K</u> | 14. <u>N</u> |
| 3. <u>H</u> | 7. <u>A</u> | 11. <u>M</u> | 15. <u>D</u> |
| 4. <u>O</u> | 8. <u>E</u> | 12. <u>C</u> | 16. <u>B</u> |

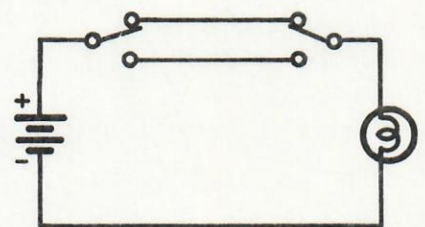
37.



38.

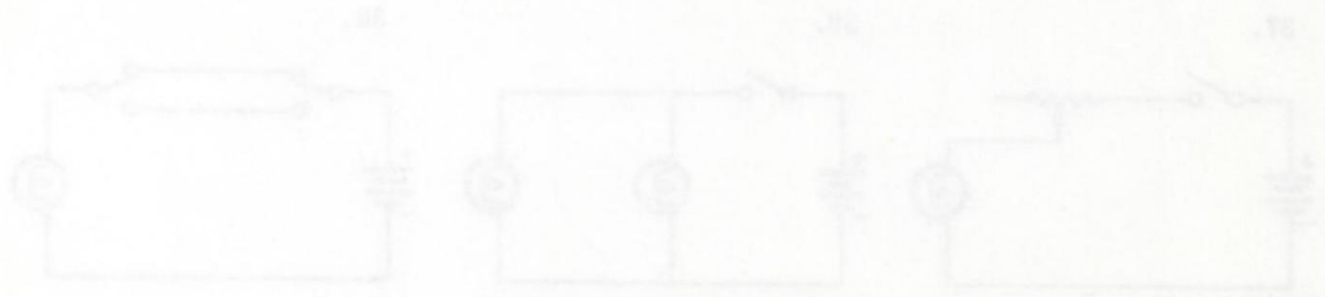


39.



1. <u>10.0</u>	2. <u>10.0</u>	3. <u>10.0</u>	4. <u>10.0</u>	5. <u>10.0</u>
6. <u>10.0</u>	7. <u>10.0</u>	8. <u>10.0</u>	9. <u>10.0</u>	10. <u>10.0</u>
11. <u>10.0</u>	12. <u>10.0</u>	13. <u>10.0</u>	14. <u>10.0</u>	15. <u>10.0</u>
16. <u>10.0</u>	17. <u>10.0</u>	18. <u>10.0</u>	19. <u>10.0</u>	20. <u>10.0</u>
21. <u>10.0</u>	22. <u>10.0</u>	23. <u>10.0</u>	24. <u>10.0</u>	25. <u>10.0</u>
26. <u>10.0</u>	27. <u>10.0</u>	28. <u>10.0</u>	29. <u>10.0</u>	30. <u>10.0</u>

1. <u>10.0</u>	2. <u>10.0</u>	3. <u>10.0</u>	4. <u>10.0</u>
5. <u>10.0</u>	6. <u>10.0</u>	7. <u>10.0</u>	8. <u>10.0</u>
9. <u>10.0</u>	10. <u>10.0</u>	11. <u>10.0</u>	12. <u>10.0</u>
13. <u>10.0</u>	14. <u>10.0</u>	15. <u>10.0</u>	16. <u>10.0</u>



NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E3

(Multiple Choice)

- | | | | | |
|-------------|-------------|--------------|--------------|--------------|
| 1. <u>a</u> | 5. <u>b</u> | 9. <u>a</u> | 13. <u>c</u> | 17. <u>b</u> |
| 2. <u>c</u> | 6. <u>a</u> | 10. <u>c</u> | 14. <u>a</u> | 18. <u>c</u> |
| 3. <u>b</u> | 7. <u>a</u> | 11. <u>d</u> | 15. <u>b</u> | 19. <u>c</u> |
| 4. <u>a</u> | 8. <u>b</u> | 12. <u>d</u> | 16. <u>a</u> | 20. <u>d</u> |

(True-False)

- | | | | | |
|--------------|--------------|--------------|--------------|--------------|
| 21. <u>F</u> | 23. <u>T</u> | 25. <u>T</u> | 27. <u>F</u> | 29. <u>T</u> |
| 22. <u>F</u> | 24. <u>T</u> | 26. <u>F</u> | 28. <u>F</u> | 30. <u>T</u> |

(Computations)

31.

- a. $0.000\ 573 = 573 \times 10^{-6}$
- b. $897,000 = 897 \times 10^3$
- c. $0.000\ 000\ 0897 = 89.7 \times 10^{-9}$
- d. $1400 \times 10^7 = 14 \times 10^9$
- e. $0.257 \times 10^4 = 2.57 \times 10^3$
- f. $5,763,970 = 5.76 \times 10^6$

ANSWER SHEET - UNIT TEST E3

32.

a.

$$\frac{2.7 \times \cancel{10^4} 10^1}{2.4 \times \cancel{10^3}} =$$

$$\underline{1.125 \times 10^1}$$

b.

$$\frac{82 \times \cancel{10^4} 10^2}{1.2 \times \cancel{10^2}} =$$

$$\underline{68.33 \times 10^2 = 6.83 \times 10^3}$$

c.

$$\frac{27.5 \times 10^3}{1.7 \times 10^{-3}} = 16.2 \times 10^6$$

$$= \underline{1.62 \times 10^7}$$

d.

$$\frac{55 \times 10^{-3}}{12 \times 10^{-6}} = 4.58 \times 10^{-3} \times 10^6$$

$$= \underline{4.58 \times 10^3}$$

e.

$$\frac{228 \times \cancel{10^3}}{5.72 \times \cancel{10^3}} = \underline{3.98 \times 10^1}$$

33.

a.

$$2809 \times 10^8 =$$

$$\underline{2.81 \times 10^{11}}$$

b.

$$(10^7)^2 = 10^{14} =$$

$$\underline{1 \times 10^{14}}$$

c.

$$\sqrt{625 \times 10^4} =$$

$$25 \times 10^2 =$$

$$\underline{2.5 \times 10^3}$$

d.

$$\sqrt{196 \times 10^8} =$$

$$14 \times 10^4 =$$

$$\underline{1.4 \times 10^5}$$

e.

$$\sqrt{484 \times 10^{-6}} =$$

$$\underline{2.2 \times 10^{-2}}$$

NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E3

34.

a. 7

f. 1

b. 2

g. 9

c. 8

h. 5

d. 0

i. 6

e. 3

j. 4

35.

a. 7

f. 4

b. 2

g. 9

c. 8

h. 6

d. 0

i. 5

e. 3

j. 1

36.

a. 10%

b. 20%

c. 5%

37.

a. $4500 \Omega \pm 5\%$

b. $10000 \pm 20\%$

ANSWER SHEET - UNIT TEST 11

1. 3	7. 4	25. 4
2. 2	8. 5	26. 5
3. 1	9. 6	27. 6
4. 2	10. 7	28. 7
5. 3	11. 8	29. 8
6. 4	12. 9	30. 9
13. 1	13. 10	31. 10
14. 2	14. 11	32. 11
15. 3	15. 12	33. 12
16. 4	16. 13	34. 13
17. 5	17. 14	35. 14
18. 6	18. 15	36. 15
19. 7	19. 16	37. 16
20. 8	20. 17	38. 17
21. 9	21. 18	39. 18
22. 10	22. 19	40. 19
23. 11	23. 20	41. 20
24. 12	24. 21	42. 21
25. 13	25. 22	43. 22
26. 14	26. 23	44. 23
27. 15	27. 24	45. 24
28. 16	28. 25	46. 25
29. 17	29. 26	47. 26
30. 18	30. 27	48. 27
31. 19	31. 28	49. 28
32. 20	32. 29	50. 29
33. 21	33. 30	51. 30
34. 22	34. 31	52. 31
35. 23	35. 32	53. 32
36. 24	36. 33	54. 33
37. 25	37. 34	55. 34
38. 26	38. 35	56. 35
39. 27	39. 36	57. 36
40. 28	40. 37	58. 37
41. 29	41. 38	59. 38
42. 30	42. 39	60. 39
43. 31	43. 40	61. 40
44. 32	44. 41	62. 41
45. 33	45. 42	63. 42
46. 34	46. 43	64. 43
47. 35	47. 44	65. 44
48. 36	48. 45	66. 45
49. 37	49. 46	67. 46
50. 38	50. 47	68. 47
51. 39	51. 48	69. 48
52. 40	52. 49	70. 49
53. 41	53. 50	71. 50
54. 42	54. 51	72. 51
55. 43	55. 52	73. 52
56. 44	56. 53	74. 53
57. 45	57. 54	75. 54
58. 46	58. 55	76. 55
59. 47	59. 56	77. 56
60. 48	60. 57	78. 57
61. 49	61. 58	79. 58
62. 50	62. 59	80. 59
63. 51	63. 60	81. 60
64. 52	64. 61	82. 61
65. 53	65. 62	83. 62
66. 54	66. 63	84. 63
67. 55	67. 64	85. 64
68. 56	68. 65	86. 65
69. 57	69. 66	87. 66
70. 58	70. 67	88. 67
71. 59	71. 68	89. 68
72. 60	72. 69	90. 69
73. 61	73. 70	91. 70
74. 62	74. 71	92. 71
75. 63	75. 72	93. 72
76. 64	76. 73	94. 73
77. 65	77. 74	95. 74
78. 66	78. 75	96. 75
79. 67	79. 76	97. 76
80. 68	80. 77	98. 77
81. 69	81. 78	99. 78
82. 70	82. 79	100. 79
83. 71	83. 80	
84. 72	84. 81	
85. 73	85. 82	
86. 74	86. 83	
87. 75	87. 84	
88. 76	88. 85	
89. 77	89. 86	
90. 78	90. 87	
91. 79	91. 88	
92. 80	92. 89	
93. 81	93. 90	
94. 82	94. 91	
95. 83	95. 92	
96. 84	96. 93	
97. 85	97. 94	
98. 86	98. 95	
99. 87	99. 96	
100. 88	100. 97	

NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E4

(Multiple Choice)

- | | | | | |
|-------------|--------------|--------------|--------------|--------------|
| 1. <u>d</u> | 6. <u>a</u> | 11. <u>a</u> | 16. <u>d</u> | 21. <u>c</u> |
| 2. <u>c</u> | 7. <u>b</u> | 12. <u>c</u> | 17. <u>b</u> | 22. <u>a</u> |
| 3. <u>c</u> | 8. <u>d</u> | 13. <u>d</u> | 18. <u>b</u> | 23. <u>d</u> |
| 4. <u>c</u> | 9. <u>a</u> | 14. <u>c</u> | 19. <u>c</u> | 24. <u>c</u> |
| 5. <u>c</u> | 10. <u>b</u> | 15. <u>c</u> | 20. <u>a</u> | 25. <u>a</u> |

(True-False)

- | | | | | |
|--------------|--------------|--------------|--------------|--------------|
| 26. <u>T</u> | 32. <u>F</u> | 38. <u>F</u> | 44. <u>F</u> | 50. <u>F</u> |
| 27. <u>F</u> | 33. <u>F</u> | 39. <u>T</u> | 45. <u>T</u> | 51. <u>T</u> |
| 28. <u>T</u> | 34. <u>F</u> | 40. <u>F</u> | 46. <u>F</u> | 52. <u>T</u> |
| 29. <u>T</u> | 35. <u>T</u> | 41. <u>T</u> | 47. <u>T</u> | 53. <u>T</u> |
| 30. <u>T</u> | 36. <u>T</u> | 42. <u>T</u> | 48. <u>T</u> | 54. <u>T</u> |
| 31. <u>T</u> | 37. <u>T</u> | 43. <u>F</u> | 49. <u>F</u> | 55. <u>F</u> |

ANSWER SHEET - UNIT TEST E4

(Problem Solving)

$$56. \quad R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{10} + \frac{1}{5} + \frac{1}{20}} = \frac{1}{0.35} = \underline{2.86 \, \Omega}$$

$$57. \quad a. \quad R_2 + R_3 = 700 + 300 = 1 \, K$$

$$1 \, K \parallel 1 \, K = 500 \, \Omega$$

$$100 + 500 + 500 = \underline{1,100 \, \Omega}$$

$$b. \quad I_T = E/R \quad 44/1100 = \underline{40 \, mA}$$

$$c. \quad E_{R1} = (I_{R1})(R1) = 0.04 \times 100 = \underline{4 \, V}$$

$$E_{R5} = (I_{R5})(R5) = 0.04 \times 500 = \underline{20 \, V}$$

$$58. \quad a. \quad I_{R1} = E/R1 = 24/6 \, K = 4 \, mA$$

$$I_{R2} = E/R2 = 24/3 \, K = 8 \, mA$$

$$I_T = I_{R1} + I_{R2} = 4 + 8 = \underline{12 \, mA}$$

$$b. \quad I_{R5} = I_T - I_{R4} = 12 - 4 = \underline{8 \, mA}$$

$$c. \quad R5 = E_{R5}/I_{R5} = 48/0.008 = \underline{6 \, K}$$

$$d. \quad E_{R3} = V_S - E_{R1} - E_{R4} = 108 - 24 - 48 = \underline{36 \, V}$$

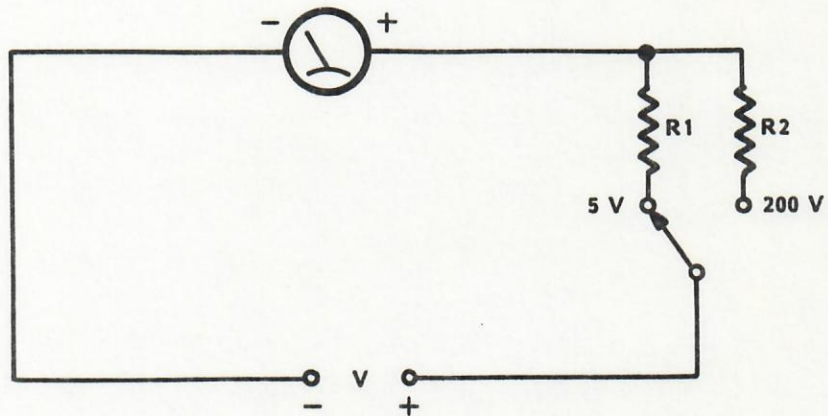
$$e. \quad R_{eq} = V_S/I_T = 108/0.012 = \underline{9 \, K}$$

ANSWER SHEET - UNIT TEST E4

(Drawings)

59.

a.



$$b. \quad R_1 = \frac{E}{I} = \frac{5}{10 \mu A} = 500 \text{ K}$$

$$R_2 = 40 \times 500 \text{ K} = \underline{20 \text{ megs.}}$$

$$c. \quad \Omega/V = \frac{R}{V} = \frac{500 \text{ K}}{5} = \underline{100 \text{ K } \Omega/V}$$

60.

$$a. \quad R_s = \frac{(I_{FS \text{ OLD}})}{(I_{FS \text{ NEW}})} R_m$$

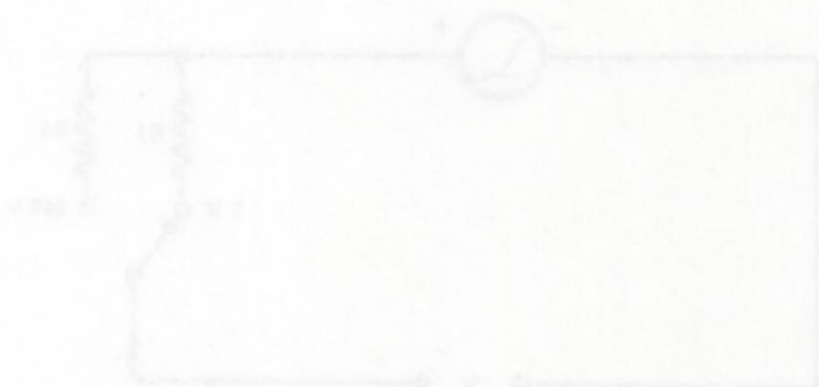
$$= \frac{0.5}{100} 1500 = \underline{7.5 \Omega}$$

$$b. \quad I_{FS \text{ NEW}} = I_{FS \text{ OLD}} \frac{(R_m)}{(R_s)}$$

$$= 50 \mu A \frac{(4000)}{(10)} = \underline{20 \text{ mA}}$$

ANSWER SHEET - UNIT TEST 12

(100 points)



$$I = \frac{V}{R} = \frac{10\text{ V}}{10\ \Omega} = 1\text{ A}$$

$$P = IV = (1\text{ A})(10\text{ V}) = 10\text{ W}$$

$$P = \frac{V^2}{R} = \frac{(10\text{ V})^2}{10\ \Omega} = 10\text{ W}$$

$$P = \frac{I^2 R}{2} = \frac{(1\text{ A})^2 (10\ \Omega)}{2} = 5\text{ W}$$

$$P = \frac{V^2}{R} = \frac{(10\text{ V})^2}{10\ \Omega} = 10\text{ W}$$

$$P = \frac{V^2}{R} = \frac{(10\text{ V})^2}{10\ \Omega} = 10\text{ W}$$

NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E5

- | | | | | |
|-------------|--------------|--------------|--------------|--------------|
| 1. <u>F</u> | 7. <u>T</u> | 13. <u>T</u> | 19. <u>T</u> | 25. <u>F</u> |
| 2. <u>T</u> | 8. <u>T</u> | 14. <u>F</u> | 20. <u>T</u> | 26. <u>F</u> |
| 3. <u>F</u> | 9. <u>F</u> | 15. <u>T</u> | 21. <u>T</u> | 27. <u>T</u> |
| 4. <u>T</u> | 10. <u>F</u> | 16. <u>T</u> | 22. <u>F</u> | 28. <u>T</u> |
| 5. <u>T</u> | 11. <u>T</u> | 17. <u>T</u> | 23. <u>T</u> | 29. <u>T</u> |
| 6. <u>F</u> | 12. <u>T</u> | 18. <u>F</u> | 24. <u>T</u> | 30. <u>T</u> |

31.

a. $R_L = R_i$ since V_S is divided equally. By Ohm's Law:

$$I = \frac{E}{R} = \frac{5 - 2.5}{1.25 \text{ K}} = 1.66 \text{ mA}$$

$$R_L = \frac{E}{I_{RL}} = \frac{2.5}{1.66} = \underline{1.5 \text{ K}}$$

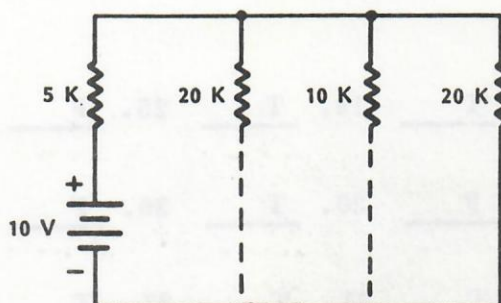
$$\begin{aligned} \text{b. } P_{RL} &= E_{RL} \cdot I_{RL} \\ &= (2.5)(1.66) \end{aligned}$$

$$P_{RL} = \underline{4.15 \text{ mW}}$$

c. Maximum P_{RL} equals 4.15 mW and is obtained when $R_L = R_i$.

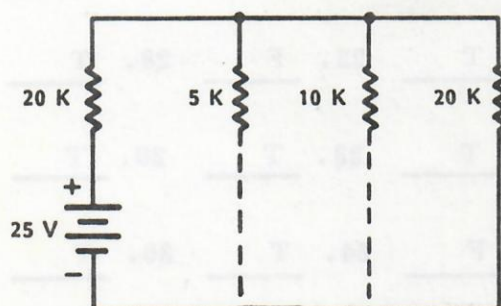
ANSWER SHEET - UNIT TEST E5

32. V_o



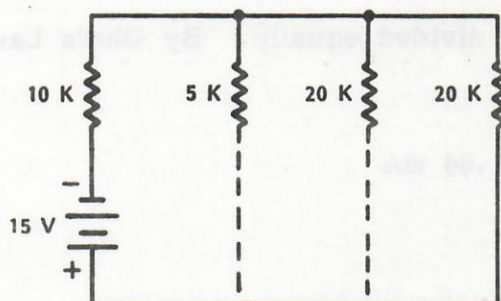
$$R_{eq} = 20 \parallel 10 \parallel 20 = 5 \text{ K}$$

$$V_o = (10) \frac{5}{5 + 5} = + 5 \text{ V}$$



$$R_{eq} = 5 \parallel 10 \parallel 20 = 2.86 \text{ K}$$

$$V_o = (25) \frac{2.86}{20 + 2.86} = + 3.13 \text{ V}$$



$$R_{eq} = 5 \parallel 20 \parallel 20 = 3.33 \text{ K}$$

$$V_o = (-15) \frac{3.33}{10 + 3.33} = - 3.75 \text{ V}$$

$$V_o = + 5 + 3.13 - 3.75$$

$$= + 4.38 \text{ V}$$

33.

a.

$$V_{Th} = (V_s) \frac{R_3}{R_1 + R_2 + R_3} =$$

$$= (20) \frac{5}{1 + 4 + 5}$$

$$= 10 \text{ V}$$

b.

$$R_{Th} = [(1 \text{ K} + 4 \text{ K}) \parallel 5 \text{ K}] + 2.5 \text{ K}$$

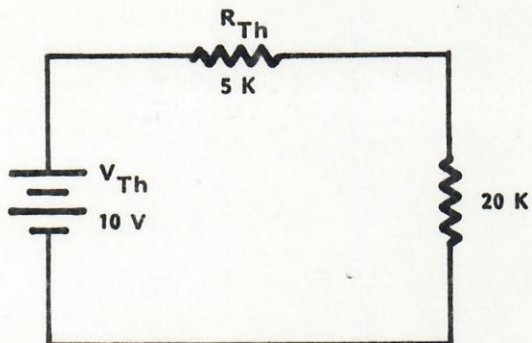
$$= 5 \text{ K}$$

NAME _____ ANSWER KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST E5

c.

V_o Loaded

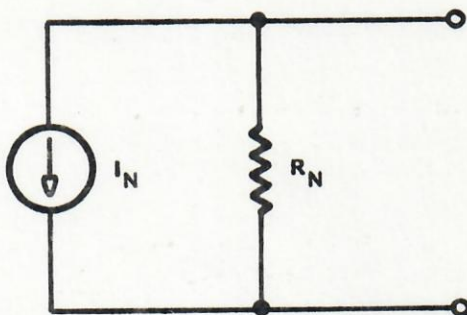


$$V_o = (10) \frac{20}{20 + 5}$$

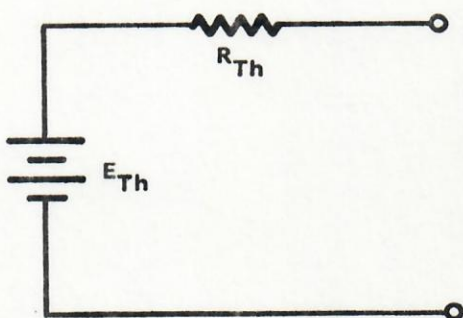
$$= (10)(0.8)$$

$$= \underline{8 \text{ V}}$$

34.



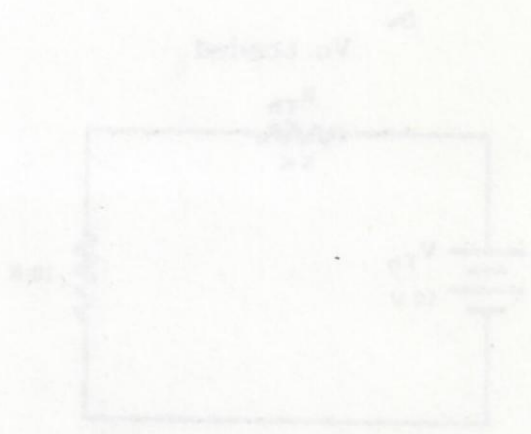
35.



$$\frac{P}{P_{max}} = 0.5$$

$$P_{max} = 100\text{ W}$$

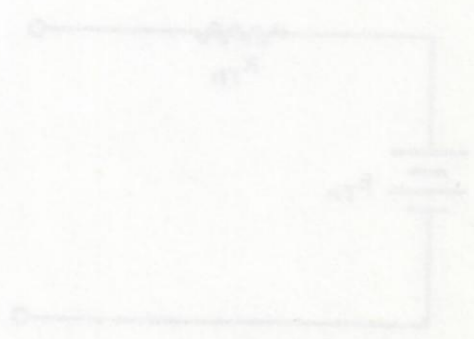
$$P = 50\text{ W}$$



27.



28.







Ed-Lab
Instructor's Manual
F1-MAGNETISM and MOTORS

CES INDUSTRIES, INC.

Name _____
Class _____
School _____

Ed-Lab Instructor's Manual

F1-MAGNETISM and MOTORS

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INFORMATION SHEET 1 - MAGNETS AND MAGNETISM

ASSIGNMENT

1. c A bar magnet.
2. b Steel.
3. d Iron filings.
4. c Both poles.
5. d All of the above.
6. b Flow from N to S.
7. b Attract.
8. a Stronger.
9. c Ferromagnetic.
10. a Material A.
11. d Slightly repelled.
12. c Slightly attracted.
13. a Strongly attracted.
14. c Each half will become a separate magnet with a N and S pole.
15. a Not magnetized.

EXPERIMENT NO. 1 - MAGNETS

PROCEDURE

3. ●No. (typical).
●Distortion of the Earth's magnetic field by the steel structure of the building.
4. ●Yes.
●Yes.
5. ●Yes
6. a Iron; Yes.
b Brass; No.
c Aluminum; No.
d Plastic; No.
9. They dropped because the soft iron was a temporary magnet.
11. Will vary with magnet and compass.
- 13.

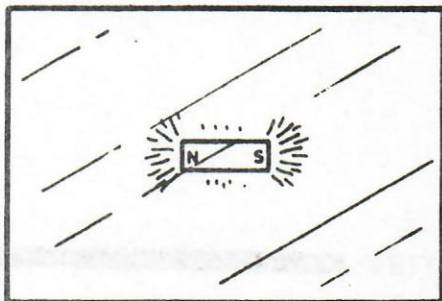


Figure 6 - Iron filing pattern.

- At the N and S poles.

14.

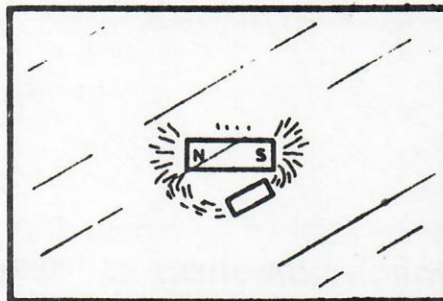


Figure 7 - Permanent magnet and soft iron bar.

15. It distorts the normal field pattern of Figure 6.

EXPERIMENT NO. 1 - MAGNETS (CONT)

17.

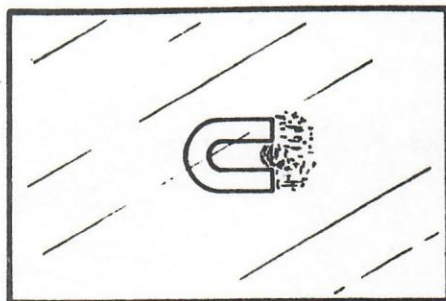


Figure 8 - Iron filing field pattern of a horseshoe magnet.

•The field is strongest between the poles where there is one cluster of filings instead of two separate clusters with a bar magnet.

19. They repel each other. The suspended magnet moves away.
20. The unlike poles attract.
22. The bright line on the screen moves away from the magnetic field.
23. The line moves away from the magnetic field but in the opposite direction.
24. The electron beam moved when the magnet was brought close to it because its own magnetic field interacted with that of the bar magnet.

ASSIGNMENT

1. F Steel structures and large areas of metal affect the accuracy of a compass adversely.
2. F A bar magnet attracts ferromagnetic materials but not para or diamagnetic materials.
3. T
4. T
5. T
6. F The field is distorted only by paramagnetic materials.
7. T
8. F Like poles repel, unlike poles attract.
9. T
10. T

INFORMATION SHEET 2 - ELECTROMAGNETISM

ASSIGNMENT

1. F The field around a straight wire has direction only but no polarity.
2. T
3. T
4. F The field strength will be directly proportional to the number of turns.

ANSWERS F1 - INFORMATION SHEET 2 (CONT)/EXPERIMENT NO. 2

INFORMATION SHEET 2 - ELECTROMAGNETISM (CONT)

5. T
6. T
7. F The thumb points to the North pole.
8. F The symbol for Magnetic Field Strength is ϕ , $\emptyset$.
9. F The symbol for Magnetic Flux Density is B.
10. T
11. T
12. F The current is determined from $\text{mmf} = AT$; $500 = A(200)$

$$A = \frac{500}{200} = \underline{2.5 \text{ A}}$$

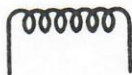
13. T

14. F Field intensity H is equal to $H = \frac{AT}{L} = \frac{500}{2} = 250$

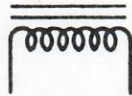
$$\text{whereas } H = \frac{500}{1} = \underline{500}$$

15. T 1.0000004 to be precise.
16. F $\mu = B/H$ not H/B .
17. T
18. T
19. F $\text{mmf} = \emptyset R$
20. T

21.



(a) Air Core
Coil



(b) Iron Core
Coil



(c) Powered Iron Core
Coil (used in Radio coils)

EXPERIMENT NO. 2 - ELECTROMAGNETS

PROCEDURE

2. •N = 55 turns (Typical).
- L = 1 1/4 inches (Typical).
7. •The pointer swings from the North to point almost to East, about a 40° swing (Typical).
- The South seeking end of the pointer swings approximately 40° to point East (Typical).
8. $I_{\text{coil}} = \underline{0.88 \text{ A}}$
9. • $\text{mmf} = (55)(0.88)$; $\text{mmf} = \underline{48.4}$ ampere turns
10. $H = \frac{(4.84)}{(1.25)}$ $H = \underline{3.872 \text{ AT/INCH}}$
14. $I_{\text{earth}} = \underline{0.034 \text{ A}}$

ANSWERS F1- EXPERIMENT NO. 2 (CONT)/EXPERIMENT NO. 3

EXPERIMENT NO. 2 - ELECTROMAGNETS (CONT)

15. $H = \frac{(55)(.034)}{(1.25)} \quad H = \underline{1.496} \text{ AT/INCH}$
16. $H_{oe} = (H_{AT/IN})(0.495) = (\underline{1.496})(0.495) \quad H_{oe} = \underline{0.74} \text{ oersteds (Typical).}$
17. Reasonably close (Typical).
21. One end of the electromagnet repels the N seeking end of the pointer. Reversing the electromagnet attracts the N seeking end.
22. •mmf = 30 AT.
•Weak. It barely picks up a small paper clip.
24. •Yes.
•The two D cells can supply almost 10 times more current than the Ed-Lab +V1 source.
25. mmf = 270 AT.

ASSIGNMENT

1. F The magnetic field exists over the full length of the wire.
2. F While it strengthens the field, coiling the wire also produces a N and S pole.
3. F The field strength around the coil is directly proportional to the current.
4. T
5. T

EXPERIMENT NO. 3 - RELAYS

PROCEDURE

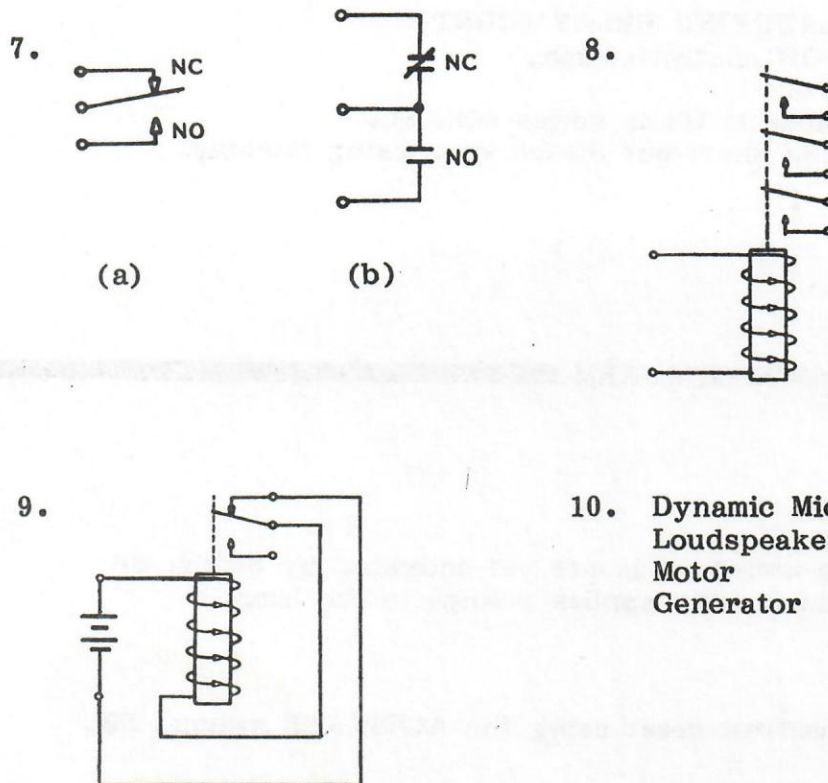
6. Yes.
7. •The relay armature moves thus pushing the contacts.
•Lamp 1 turns off and Lamp 2 turns on.
9. Pull-In Voltage = 6.9 V (Typical).
12. Drop-Out Voltage = 1.8 V (Typical).
14. •The armature lever hitting the electromagnet core, releasing and hitting repeatedly.
•Buzz Stops at 5.8 V
•The pitch increases as the voltage is lowered.

ASSIGNMENT

1. T
2. F It will operate at approximately 75% of the nominal voltage.
3. F It will hold the armature in until the voltage drops to approximately 10% of nominal or less.
4. T
5. T
6. T

ANSWERS F1 - EXPERIMENT NO. 3 (CONT)/EXPERIMENT NO. 4

EXPERIMENT NO. 3 - RELAYS (CONT)



10. Dynamic Microphone
Loudspeaker
Motor
Generator

EXPERIMENT NO. 4 - LATCHING RELAY

PROCEDURE

- 5. Yes.
- 6. Yes.
- 8. Yes.
- 9. Lamp 1 remains on. Switch SA no longer controls the relay.
- 12. Yes.
- 13. Yes.
- 15. Yes.

ASSIGNMENT

- 1. b Ladder diagram.
- 2. c Sa is used to turn the motor on.
- 3. a CRa is a normally open pair of contacts controlled by CR.
- 4. d All of the above.
- 5. b CRb is a normally closed set of contacts.
- 6. d All of the above.

ANSWERS F1 - EXPERIMENT NO. 4 (CONT)/EXPERIMENT NO. 5

EXPERIMENT NO. 4 - LATCHING RELAY (CONT)

7. a Switch Sb is an Off control switch.
8. d None of the above.
9. a Add a switch similar to Sb in series with Sb.
10. a Relay contacts CRa short out Switch Sa causing latching.

EXPERIMENT NO. 5 - BURGLAR ALARM

PROCEDURE

3. ●No.
●No.
4. ●Yes.
●While the circuit is armed, it is not yet activated by Switch SB and so the deenergized relay applies voltage to the lamp.
5. Yes.
6. ●Yes.
●No.
●Yes, if the alarm is first reset using the ACTIVATE switch, SB.
9. ●Yes.
●Yes.
10. ●Yes.

ASSIGNMENT

1. T
2. F The sensor switches must be wired in series only.
3. T
4. T
5. T
6. T
7. F Switch S1 in Figure 10 is to Arm/Disarm the circuit.
8. F Switch S5 in Figure 10 is to set the alarm.
9. F Contacts CRa and CRb are magnetically operated by the relay coil CR1 but, CRa is NC and CRb is NO.
10. F The sensor switches must be in series not parallel.

ANSWERS F1 - INFORMATION SHEET 3/EXPERIMENT NO. 6

INFORMATION SHEET 3 - ELECTROMAGNETIC INDUCTION

ASSIGNMENT

1. F When the bar magnet is inserted as shown in Figure 4 a VOLTAGE will be developed between A and B. No current can flow as the AB circuit is open.
2. T
3. F When the magnet is withdrawn from the coil a voltage will be developed that is opposite in polarity to the voltage developed when the magnet was inserted.
4. T
5. T
6. T
7. F Faraday's law allows the determination of the output voltage amplitude, not polarity.
8. T
9. T
10. F If the flux is constant around the coil there is no induced voltage. Movement of the magnetic field or the coil is necessary.

EXPERIMENT NO. 6 - ELECTROMAGNETIC VOLTAGE INDUCTION

PROCEDURE

3. Will vary with coil connection and magnet strength.
4. ●Pointer will move in the opposite direction that it moved in step 3.
●Reverses the voltage and current polarity.
5. Reversing polarity of the magnet reverses the polarity of the induced voltage.
6. There is no induced voltage and thus no current flow.
9. ●Much greater induced voltage.
●It reverses.
10. The slow movement greatly reduces the induced voltage level.
11. The induced voltage polarities reverse.
12. There is no induced voltage without movement.

ASSIGNMENT

1. F If a conductor is sitting in a stationary field there will be no induced voltage. Movement of the flux or the coil is required.
2. T
3. T
4. F The induced voltage would be four times greater if both the flux and the number of turns were doubled. When reducing the number of turns by half it serves to cancel the flux doubling and the induced voltage will remain unchanged.

ANSWERS F1 - EXPERIMENT NO. 6 (CONT)/INFORMATION SHEET 4/
EXPERIMENT NO. 7

EXPERIMENT NO. 6 - ELECTROMAGNETIC VOLTAGE INDUCTION (CONT)

5. F A magnetic field can exist without motion but cannot induce a voltage.

INFORMATION SHEET 4 - DC MOTORS AND GENERATORS

ASSIGNMENT

1. F An electric motor is used to convert electrical energy into mechanical energy.
2. T
3. F The repulsion-attraction phenomena will create only 180 degrees of rotation. The applied voltage polarity must be reversed for the second 180 degree rotation.
4. T
5. T
6. T
7. T
8. T
9. F For 8 armature windings only 8 commutator segments are needed. (See Figure 9.)
10. F An increase in armature current increases torque.
11. T
12. T
13. T
14. F The motor rpm decreases with added load.
15. T
16. T
17. F Motor efficiency is equal to $P_{out} / P_{in} \times (100)$.
18. F A generator is used to generate electrical energy.
19. T
20. T

EXPERIMENT NO. 7 - DC MOTOR OPERATION

PROCEDURE

1. CES 309 Motor Tach.
3. •Starting Voltage = 1 VDC.
 - The higher the voltage the faster the motor rotation.
 - As the applied voltage is increased, the current drain increases.

ANSWERS F1 - EXPERIMENT NO. 7 (CONT)

EXPERIMENT NO. 7 -DC MOTOR OPERATION (CONT)

4.

SPEED	VOLTAGE	CURRENT
LOW	1 V	25 mA
MEDIUM	3 V	34 mA
HIGH	6 V	42 mA

5. A load causes the motor speed to drop and the load current to increase. This current increase is due to the reduced CEMF.
6. As the torque is increased the motor slows down and finally stalls. The current drain exceeds 100 mA and the meter pointer goes off scale.
7. Stalled motor voltage at 100 mA current = 1.89 V
8. ●Rotating motor current drain = 30 mA.
●When the armature is rotating a CEMF is developed that cancels V_{in} and so reduces the current drain.
9. Armature resistance = 18.9 Ω
10. $CEMF = (1.89) - (0.03)(18.9) = (1.89) - (0.567)$
 $CEMF = \underline{1.323 \text{ V (Typical)}}$
11. $I_M = \underline{44 \text{ mA (Typical)}}$
12. $CEMF = (6) - (I_M R_A) = (6) - (.044)(18.9) = (6) - (0.8316)$
 $CEMF = \underline{5.168 \text{ V (Typical)}}$
13. Clockwise.
14. ●The direction of rotation reverses.
●It too reverses as the direction of current flow has reversed.
16. Clockwise.
17. The motor reverses direction and now rotates counter clockwise.
18. $\text{Input Power}_m = (E)(I) = (6)(I_M) = (6)(0.044)$
 $\text{Input Power}_m = \underline{0.264 \text{ Watts}}$
19. $P_{out} = (P_{in})(\text{Efficiency Factor}) = (0.264)(0.8)$
 $P_{out} = \underline{0.211 \text{ Watts}}$
20. $hp = \frac{P_{out}}{746} = \frac{(0.211)}{746} = \underline{283 \times 10^{-6} \text{ hp}}$
21. $\text{Torque} = \frac{hp}{(0.00019)(rpm)} = \frac{(283 \times 10^{-6})}{(0.00019)(200)}$ Torque = 0.00745 ft-lbs
Torque in oz-in = Torque in ft-lbs (12)(16) = (0.00745)(192)
Torque = 1.43 oz-in

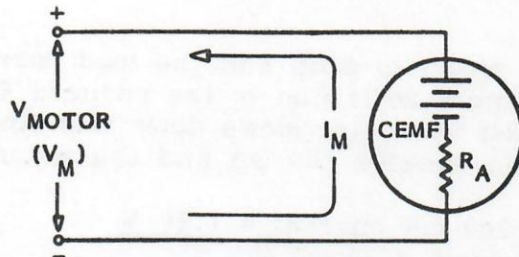
ASSIGNMENT

1. T
2. F Speed indication of a tachometer is directly proportional to output voltage.
3. T
4. F The statement would be true if 0.2 volts were enough to overcome the starting torque, but it is not.

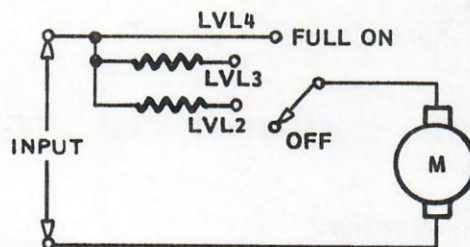
ANSWERS F1 - EXPERIMENT NO. 7 (CONT)/EXPERIMENT NO. 8

EXPERIMENT NO. 7 - DC MOTOR OPERATION (CONT)

5. F When the motor input voltage is doubled the armature rpm increases, increasing the CEMF. This lowers the current drain of the motor.
6. T
7. F Motor speed decreases with a load and thus the CEMF must also decrease. This results in an increased motor current.
8. F Armature resistance is a function of the number of turns of wire and parallel windings and not the armature speed.
9. T
10. T
- 11.



12.



$$13. R_{ARM} = \frac{E_{APP}}{I_{ARM}} = \frac{120}{2} = 60 \Omega$$

$$14. CEMF = V_M - (I_M \times R_A) = 120 - (1.5)(30) \quad CEMF = \underline{75 \text{ V}}$$

EXPERIMENT NO 8 - GENERATORS AND MOTOR GENERATOR SETS

PROCEDURE

3. •A maximum output of 2 volts (typical) only when the shaft is spinning.
•The generator output voltage polarity reverses.

ANSWERS F1 - EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - GENERATORS AND MOTOR GENERATOR SETS (CONT)

5. •In one direction of rotation only.
 •The LED will light only when forward biased, that is, negative to the bar and positive to the arrow.
 •Yes.
8. In step 8, when the generator is loaded, a much greater effort is required to rotate the shaft and the shaft stops rotating very quickly; it will not coast.
11. •The input current rises gradually. At 30 mA the motor starts to rotate the generator. At the full +V1, 9 V, the current drain is 52 mA, I_{IN} .
 •The output voltage gradually increases with motor speed to a maximum of 7 volts out.
 •The motor speed increases as +V1 is increased.
- 13.

LOAD		SWITCHES	I_{IN}	V_{OUT}
a.	NO LOAD	A & B DOWN	53 mA	7 V
b.	500 Ω LOAD ONLY	A DOWN, B UP	76 mA	6 V
c.	LAMP ONLY	A UP, B DOWN	109 mA	5.2 V
d.	500 Ω PLUS LAMP	A & B UP	127 mA	4.7 V

TABLE 1 - Motor input current versus generator load and output voltage.

15. •Increases.
 •Decreases.
16. $P_{IN (b)} = V_{IN} I_{IN} = (9V)(0.076) \quad P_{IN (b)} = \underline{684 \text{ mW}}$
17. $P_{OUT (b)} = \frac{V_{OUT}^2}{R} = \frac{(6)^2}{500} = \frac{36}{500} = \underline{72 \text{ mW}}$
18. $\% \text{ Eff} = \frac{P_{OUT}}{P_{IN}} \times 100 = \frac{(72)}{(684)} \times 100 = \underline{10.53 \%}$
19. $I_{OUT} = \frac{V_{OUT}}{R_{load}} = \frac{(6)}{(500)} = \underline{0.012 \text{ Amps}}$
20. $P_{LOSS} = I^2 R_{ARM} = (I_{OUT})^2 (R_{ARM}) = (0.012)^2 (19) = \underline{2.736 \text{ mW}}$
21. $V = I_{OUT} R_{ARM} = (0.012)(19) = \underline{0.23 \text{ V}}$
22. a $P_{IN} = E_{IN} \times I_{IN} = (12)(93) = \underline{1,116 \text{ Watts}}$
 b $P_{OUT} = E_{OUT} I_{OUT} = (120)(8) = \underline{960 \text{ Watts}}$
 c $\% \text{ Efficiency} = \frac{P_{OUT}}{P_{IN}} \times 100 = \frac{(960)}{(1,116)} \times 100 = \underline{86 \%}$

ANSWERS F1 - EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - GENERATORS AND MOTOR GENERATOR SETS (CONT) 25.

SPEED	V _{OUT}
ZERO (+V1 = 0 V)	0 V
LOW	2 V
MEDIUM	4 V
HIGH (+V1 = 9 V)	7.2 V

(Typical)

TABLE 2 - Speed versus output voltage.

•The output voltage increases as the speed of the generator increases.

26. Selected output voltage 1 V (Typical).

27. •30 Second rotation count = 20 (Typical).

•RPM = 30 second count $\times 2 = (20) (2) = \underline{40}$

28. Scale Factor = $\frac{\text{RPM}}{V_{\text{OUT}}} = \frac{(40)}{1} = \underline{40 \text{ RPM/VOLT.}}$

29. $V_{200 \text{ RPM}} = \frac{200 \text{ RPM}}{\text{SCALE FACTOR } (40)} = \frac{200}{40} = \underline{5 \text{ volts}}$

30. Adjusted the motor speed so that the generator output read 5 V, which is the equivalent of 200 rpm.

32. $V_{200 \text{ RPM}} = \underline{5 \text{ V.}}$

37.

LOAD CURRENT mA	OUTPUT VOLTAGE
40	4.5
30	5.15
20	5.6
10	5.94
0	6.85

(Typical)

TABLE 4 - Output voltage versus load current.

39.

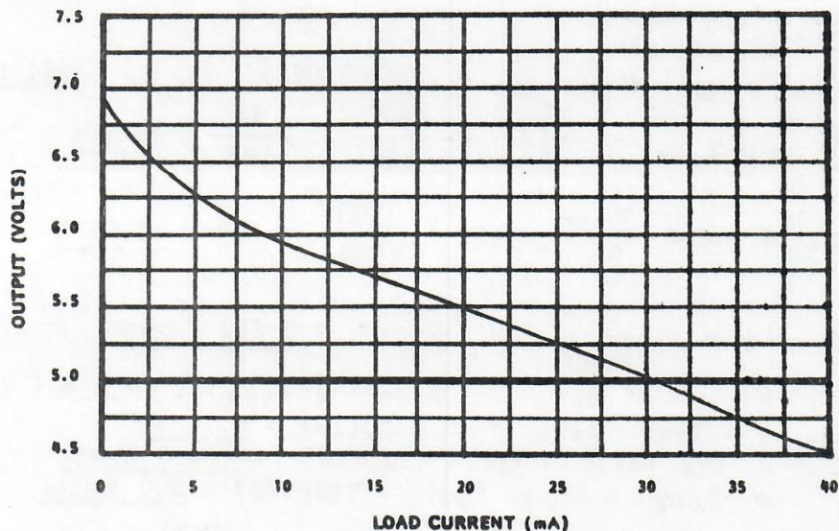


Figure 12 - Generator Output Voltage versus Load Current characteristics; EXPERIMENT.

40. •Yes.

$$\% \text{ change} = \frac{E_{\text{NL}} - E_{\text{FL}}}{E_{\text{FL}}} \times 100 = \frac{(6.85) - (4.5)}{(4.5)} \times (100) = \underline{52.2 \%}$$

•No.

ANSWERS F1 - EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - GENERATORS AND MOTOR GENERATOR SETS (CONT) 42.

LOAD CURRENT mA	OUTPUT VOLTAGE	
0	5	E_{NL} (NO-LOAD)
10	5	
20	5	
30	5	
40	5	E_{FL} (FULL-LOAD)

TABLE 5 - Corrected output voltage versus load current; EXPERIMENT.

44. •The data from Table 5 above produces a flat curve indicating perfect regulation.

$$\bullet \% \text{regulation} = \frac{E_{NL} - E_{FL}}{E_{FL}} \times 100 = \frac{(5) - (5)}{(5)} \times (100) = \underline{0 \%}$$

ASSIGNMENT

1. F The M-G combination on a common shaft is called a DYNAMOTOR, not a dynamometer. A dynamometer is a device used to measure force.
2. T
3. T
4. F As the current load on a generator is increased, the shaft becomes more difficult to turn.
5. F As the current load on a generator is increased its shaft becomes harder to turn. This places a heavier load on the motor, slowing it down, thus increasing the current drain.
6. T
7. T
8. T
9. F For 500 rpm to 1 volt with a 5 volt output rpm is equal to $500 \times 5 = 2500$ rpm.
10. F $\% \text{ Regulation} = \frac{E_{NL} - E_{FL}}{E_{NL}} \times 100$
11. (a) Internal generator voltage drop.
 $E_{\text{internal}} = E_{NL} - E_{FL} = 50 - 40 = \underline{10 \text{ volts}}$
- (b) $I_{\text{load}} \quad I_L = \frac{E_{\text{OUT}}}{R_L} = \frac{40}{80} = \underline{0.5 \text{ A}}$
- (c) Internal generator resistance.
 $R_{\text{gen}} = \frac{E_{\text{LOSS}}}{I_{\text{LOAD}}} = \frac{10}{0.5} = \underline{20 \Omega}$
- (d) Generator $\% \text{ Regulation} \quad \% \text{ Regulation} = \frac{E_{NL} - E_{FL}}{E_{NL}} \times 100$
 $= \frac{50 - 40}{50} \times 100 = \frac{10}{50} \times 100 = \underline{20 \%}$

ANSWERS F1 - INFORMATION SHEET 5

INFORMATION SHEET 5 - FORCES AND RESISTANCE

ASSIGNMENT

1. T
2. T
3. F One of the wires has a resistance one fourth of the other.
4. T Doubling the length will increase the resistance from 50 to 100 ohms. Doubling the diameter will reduce the resistance by one fourth. One fourth of 100 is 25 ohms.
5. F It is equal to 3 mils squared or 9, not 0.003^2 which is 9×10^{-6} .
6. T
7. T
8. T
9. T
10. F $R = \frac{1}{G} = \frac{1}{0.00001} = \underline{100,000 \Omega}$

Unit Test

F1—Magnetism and Motors

UNIT TEST

Part F1—Magnetism and Motors

Answer the following True-False questions.

1. A permanent magnet can be made using soft iron. _____
2. The magnetic field of a bar magnet is strongest at the center of the bar. _____
3. Magnetic lines of force are said to flow from the North to the South pole. _____
4. Iron is a ferromagnetic material. _____
5. Given a choice between two pieces of steel, one with a permeability of 2,560 and the other with a permeability of 1,250, the best permanent magnet can be made with the higher permeability. _____
6. The strength of the magnetic field around a wire is directly proportional to the wire length. _____
7. Ferromagnetic materials, when placed in a magnetic field, will be strongly attracted. _____
8. A soft iron core added to the center of an air core coil increases the number of lines of force in the core area. _____
9. When the left hand rule is applied to a coil the thumb will point in the direction of the South pole. _____
10. The magnetic flux density, B , is the number of magnetic flux lines in a cross sectional area of the core measured in square inches or square meters or square centimeters. _____
11. Given a magnetomotive force (mmf) of 2100 and a coil of 150 turns, the coil current is equal to 20 amperes. _____
12. Magnetic field intensity is defined by the letter H . _____
13. The μ of air is approximately equal to 1. _____
14. It is possible to calculate permeability from H/B . _____

Part 1 - The General Principles

1. The first principle is that the law is a system of rules which are applied to the facts of a case.
2. The second principle is that the law is a system of rules which are applied to the facts of a case.
3. The third principle is that the law is a system of rules which are applied to the facts of a case.
4. The fourth principle is that the law is a system of rules which are applied to the facts of a case.
5. The fifth principle is that the law is a system of rules which are applied to the facts of a case.
6. The sixth principle is that the law is a system of rules which are applied to the facts of a case.
7. The seventh principle is that the law is a system of rules which are applied to the facts of a case.
8. The eighth principle is that the law is a system of rules which are applied to the facts of a case.
9. The ninth principle is that the law is a system of rules which are applied to the facts of a case.
10. The tenth principle is that the law is a system of rules which are applied to the facts of a case.

15. Faraday's law states that a wire or coil that is moved through a magnetic field will have a voltage induced in it. _____
16. Lenz's law states that the polarity of the induced voltage in a coil will cause a current flow in that coil that will aid the changing magnetic flux. _____
17. The polarity of the voltage applied to the armature of a dc motor is reversed by the brush and commutator assembly. _____
18. The direction of rotation of a dc permanent magnet motor can be reversed only by reversal of the applied voltage polarity. _____
19. The current drawn by a motor is a function of the counter emf developed by the armature, the dc resistance of the armature and the applied voltage. _____
20. The greater the motor speed the greater the counter emf and the greater the power line current drain. _____
21. The speed of a dc permanent magnet motor is directly proportional to the applied voltage. _____
22. A dc motor can be used as a dc generator. This is called reciprocity. _____
23. As the current drain from the generator is increased, the counter emf generated increases. _____
24. A relay is an electromagnetically operated switch. _____
25. A relay designed for a nominal voltage rating of 32 volts requires the full 32 volts to pull in the armature. _____
26. The relay drop-out voltage is always lower than the relay pull-in voltage. _____

1. The purpose of this document is to provide a comprehensive overview of the project's objectives, scope, and deliverables.

2. The project is designed to address the current challenges faced by the organization and to implement a solution that meets the needs of the stakeholders.

3. The project will be managed in accordance with the principles of project management, ensuring that the project is completed on time, within budget, and to the satisfaction of the stakeholders.

4. The project team will be responsible for the successful completion of the project, and will report progress to the project sponsor and the steering committee.

5. The project will be subject to regular communication and reporting, ensuring that all stakeholders are kept informed of the project's progress and any issues that may arise.

6. The project will be completed by the end of the year, and the results will be evaluated against the project's objectives and the needs of the stakeholders.

7. The project team will be responsible for the successful completion of the project, and will report progress to the project sponsor and the steering committee.

8. The project will be subject to regular communication and reporting, ensuring that all stakeholders are kept informed of the project's progress and any issues that may arise.

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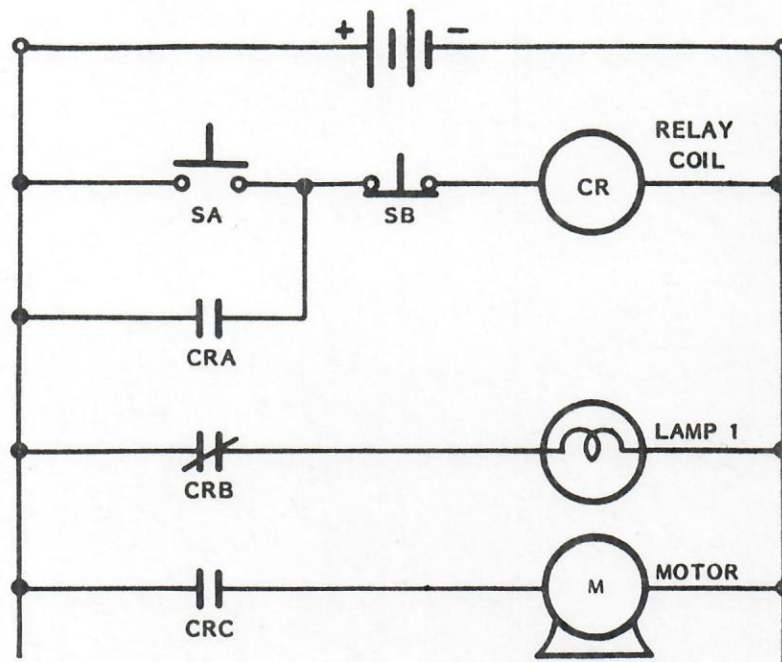


Figure 1 refers to questions 27 to 32.

27. The drawing format of Figure 1 is called a ring diagram. _____
28. Switch SA in Figure 1 is a momentary contact NO type used as the START switch. _____
29. CRA in Figure 1 is a normally open set of relay contacts used to lock up the relay coil. _____
30. When SA in Figure 1 is depressed, the relay coil is energized, Lamp 1 turns off and the motor turns on. _____
31. Contact CRC in Figure 1 is NC and turns the motor on when the relay coil is energized. _____
32. To add a second OFF switch to Figure 1, it must be a NO type placed in parallel with switch SA. _____
33. The voltage induced in a coil that is sitting in a fixed magnetic field is determined by the field strength and the number of turns on the coil. _____



Figure 1. Three-phase system.

1. The three-phase system is a system of three alternating currents of the same frequency and amplitude, displaced by 120 degrees in phase.
2. The three-phase system is the most common type of AC power system used in industry and commerce.
3. The three-phase system is used for the transmission and distribution of power.
4. The three-phase system is used for the generation of power.
5. The three-phase system is used for the conversion of power from one form to another.
6. The three-phase system is used for the control of power.
7. The three-phase system is used for the measurement of power.
8. The three-phase system is used for the protection of power.
9. The three-phase system is used for the regulation of power.
10. The three-phase system is used for the synchronization of power.

34. Reversing the polarity of the magnetic field reverses the polarity of the voltage induced in a coil in that field. _____
35. The voltage induced in a coil in a moving magnetic field will double if the number of lines of flux are doubled. _____
36. The voltage induced in a coil will decrease as the speed of the movement of the magnetic field is increased. _____
37. A magnetic field does not exist without motion. _____
38. A tachometer, used to measure rpm, is basically a dc generator with a voltmeter across the generator output with the meter face calibrated in rpm. _____
39. As the mechanical load on a motor shaft is increased, the motor draws more current from the power line. _____
40. The armature resistance of a dc motor increases with speed and applied voltage. _____
41. The output polarity of a dc motor-generator will reverse if the direction of the shaft rotation is reversed. _____
42. As the current load on a generator output is increased, the generator shaft becomes easier to drive. _____
43. Motor-generators, when used, change dc to a higher value of dc or to ac. _____
44. A dc motor or generator may use permanent magnet type fields only. _____
45. The speed of a dc permanent magnet motor is directly proportional to the applied voltage. _____

1. The first step in the process of the system is to identify the problem or need that the system is intended to address.

2. The second step is to define the scope of the system, including the boundaries of the system and the specific objectives that the system is intended to achieve.

3. The third step is to analyze the problem or need, identifying the causes and effects of the problem and the specific requirements that the system must meet.

4. The fourth step is to design the system, including the selection of the appropriate technology and the development of the system architecture.

5. The fifth step is to implement the system, including the installation of the hardware and software components and the training of the users.

6. The sixth step is to evaluate the system, assessing the system's performance against the defined objectives and identifying any areas for improvement.

7. The seventh step is to maintain the system, ensuring that the system remains up-to-date and functioning properly over its lifetime.

8. The eighth step is to document the system, creating a comprehensive record of the system's design, implementation, and operation.

9. The ninth step is to communicate the system, sharing the system's benefits and capabilities with the relevant stakeholders.

10. The tenth step is to monitor the system, tracking the system's performance and identifying any issues or opportunities for improvement.

11. The eleventh step is to update the system, making any necessary changes to the system's design or implementation to keep it current and effective.

12. The twelfth step is to retire the system, decommissioning the system and its components when it is no longer needed or when a new system is implemented.

46. Match the listing in the left hand column with the formulas in the right hand column.

1. μ	_____	A. Force x Radius
2. B	_____	B. NI
3. H	_____	C. $\text{mmf} = \phi \mathcal{R}$
4. mmf	_____	D. B/H
5. ϕ	_____	E. $L/\mu A$
6. E_{induced}	_____	F. ϕ/A
7. Reluctance, $\mathcal{R}$	_____	G. $0.00019 \times \text{Torque} \times \text{RPM}$
8. μ of Air	_____	H. NI/L
9. Magnetic Ohm's Law	_____	I. $\frac{E_{NL} - E_{FL}}{E_{FL}} \times 100$
10. Motor Torque	_____	J. Total magnet flux
11. Motor Horsepower	_____	K. approximately 1
12. Generator Output Regulation	_____	L. $N \frac{\Delta \phi}{\Delta t}$
		M. T/F
		N. RPM

Perform the following calculations.

47. A relay has a resistance of 750 ohms and a voltage rating of 120 volts. The relay is to be operated from a 240 volt line.
- Draw the circuit showing how this can be done.
 - Calculate the value of any components that have to be used.

48. Calculate the horsepower generated by a motor that has a torque of 6 foot-lbs and an rpm of 1750.
49. A motor delivers 1 horsepower to its load and draws 1200 watts from the power line. Calculate the motor efficiency in percentage.
50. A stalled motor draws 2A from the 120 volt line and 0.5A when running.
- a. Calculate the dc field resistance.
 - b. Calculate the counter emf when running.

1. The purpose of this document is to provide information regarding the project and to ensure that all stakeholders are aware of the project's progress and any changes that may occur.

2. The project is currently in the planning phase and is expected to be completed by the end of the year. The project team is working closely with the client to ensure that the project meets their requirements and expectations.

3. The project team is currently reviewing the project plan and identifying any potential risks or issues that may arise. The team is also working on developing a detailed schedule and timeline for the project.

4. The project team is also working on developing a communication plan to ensure that all stakeholders are kept up-to-date on the project's progress and any changes that may occur.

5. The project team is also working on developing a risk management plan to identify and mitigate any potential risks or issues that may arise during the project.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST F1

True or False

- | | | | | |
|----------|-----------|-----------|-----------|-----------|
| 1. _____ | 10. _____ | 19. _____ | 28. _____ | 37. _____ |
| 2. _____ | 11. _____ | 20. _____ | 29. _____ | 38. _____ |
| 3. _____ | 12. _____ | 21. _____ | 30. _____ | 39. _____ |
| 4. _____ | 13. _____ | 22. _____ | 31. _____ | 40. _____ |
| 5. _____ | 14. _____ | 23. _____ | 32. _____ | 41. _____ |
| 6. _____ | 15. _____ | 24. _____ | 33. _____ | 42. _____ |
| 7. _____ | 16. _____ | 25. _____ | 34. _____ | 43. _____ |
| 8. _____ | 17. _____ | 26. _____ | 35. _____ | 44. _____ |
| 9. _____ | 18. _____ | 27. _____ | 36. _____ | 45. _____ |

Matching

46.

- | | | |
|----------|----------|-----------|
| 1. _____ | 5. _____ | 9. _____ |
| 2. _____ | 6. _____ | 10. _____ |
| 3. _____ | 7. _____ | 11. _____ |
| 4. _____ | 8. _____ | 12. _____ |

NAME _____ CLASS _____ DATE _____

Calculations

47. a.

b.

48.

49.

50. a.

b.

UNIT TEST

Part F1—Magnetism and Motors

Instructor's Answer Sheet

1. F Soft iron can only be used for a temporary magnet. Steel is used for permanent types.
2. F The magnetic field of a bar magnet is strongest at the ends, the poles.
3. T
4. T
5. T
6. F The magnetic field strength around a wire is inversely proportional to wire length (resistance) and directly proportional to current flow.
7. T
8. T
9. F The thumb will point in the direction of the N pole.
10. T
11. F $\text{mmf} = NI$
 $2100 = 150 I$
 $I = \frac{2100}{150} = \underline{14 \text{ A}}$
12. T
13. T
14. F $\mu = B/H$
15. T
16. F The induced voltage in a coil will cause a current flow that generates a field that opposes the changing flux.
17. T
18. T
19. T
20. F As the CEMF increases it reduces the power line drain.

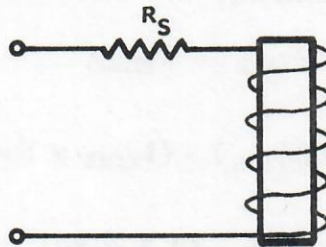
2—UNIT TEST FOR PART F1 (ANSWERS)

- 21. T
- 22. T
- 23. T
- 24. T
- 25. F The relay will pull-in at some voltage less than the nominal rating.
- 26. T
- 27. F The drawing of Figure 1 is called a LADDER DIAGRAM.
- 28. T
- 29. T
- 30. T
- 31. F Contact CRC is NO and turns the motor on when the relay coil is energized.
- 32. F The second OFF switch must be NC and placed in series with SB of Figure 1.
- 33. F No voltage is induced in a coil that sits in a fixed magnetic field.
- 34. T
- 35. T
- 36. F The induced voltage in a coil will increase as the speed of movement is increased thus decreasing Δt .

$$E_{\text{ind}} = N \frac{\Delta \phi}{\Delta t}$$

- 37. F A magnetic field does exist without motion.
- 38. T
- 39. T
- 40. F The armature resistance of a dc motor is a function of the dc resistance of the armature winding and so does not vary with speed.

41. T
42. F As the current load on a generator is increased, the shaft of the generator becomes more difficult to rotate (Lenz's Law).
43. T
44. F The field excitation for a dc motor or generator can be provided by permanent magnets or electromagnets (field windings).
45. T
- 46.
- | | |
|------|-------|
| 1. D | 7. E |
| 2. F | 8. K |
| 3. H | 9. C |
| 4. B | 10. A |
| 5. J | 11. G |
| 6. L | 12. I |
47. a.



b.

$$R_S = \text{Relay } R \quad R_S = \underline{750 \, \Omega} \quad \text{or}$$

$$R_S = \frac{E_{RS}}{I_{RS}} = \frac{240-120}{\frac{120}{750}} = \frac{120}{.16} = \underline{750 \, \Omega}$$

48.

$$\text{HP} = 0.00019 (\text{TORQUE}) (\text{RPM})$$

$$= 0.00019 (6) (1750)$$

$$\text{HP} = \underline{2}$$

4—UNIT TEST FOR PART F1 (ANSWERS)

49. Given that 1 hp = 746 watts

$$\text{Eff} = \frac{P_{\text{OUT}}}{P_{\text{IN}}} \times 100 = \frac{746}{1200} \times 100$$

$$\text{Eff} = \underline{62\%}$$

50. a.

$$\text{Dc Field Resistance} = \frac{E_{\text{APPLIED}}}{I}$$

$$= \frac{120}{2}$$

$$\text{Dc Field Resistance} = \underline{60 \text{ ohms}}$$

b. When running, the CEMF is

$$\text{CEMF} = E_{\text{LINE}} - E_{\text{FIELD}}$$

$$= (E_{\text{LINE}}) - (I_{\text{LINE}} \times R_{\text{FIELD}})$$

$$= (120) - (0.5 \times 60)$$

$$= (120) - (30)$$

$$\text{CEMF} = \underline{90 \text{ VOLTS}}$$

NAME _____ MARKING KEY _____ CLASS _____ DATE _____

ANSWER SHEET - UNIT TEST F1

True or False

- | | | | | |
|-------------|--------------|--------------|--------------|--------------|
| 1. <u>F</u> | 10. <u>T</u> | 19. <u>T</u> | 28. <u>T</u> | 37. <u>F</u> |
| 2. <u>F</u> | 11. <u>F</u> | 20. <u>F</u> | 29. <u>T</u> | 38. <u>T</u> |
| 3. <u>T</u> | 12. <u>T</u> | 21. <u>T</u> | 30. <u>T</u> | 39. <u>T</u> |
| 4. <u>T</u> | 13. <u>T</u> | 22. <u>T</u> | 31. <u>F</u> | 40. <u>F</u> |
| 5. <u>T</u> | 14. <u>F</u> | 23. <u>T</u> | 32. <u>F</u> | 41. <u>T</u> |
| 6. <u>F</u> | 15. <u>T</u> | 24. <u>T</u> | 33. <u>F</u> | 42. <u>F</u> |
| 7. <u>T</u> | 16. <u>F</u> | 25. <u>F</u> | 34. <u>T</u> | 43. <u>T</u> |
| 8. <u>T</u> | 17. <u>T</u> | 26. <u>T</u> | 35. <u>T</u> | 44. <u>F</u> |
| 9. <u>F</u> | 18. <u>T</u> | 27. <u>F</u> | 36. <u>F</u> | 45. <u>T</u> |

Matching

46.

- | | | |
|-------------|-------------|--------------|
| 1. <u>D</u> | 5. <u>J</u> | 9. <u>C</u> |
| 2. <u>F</u> | 6. <u>L</u> | 10. <u>A</u> |
| 3. <u>H</u> | 7. <u>E</u> | 11. <u>G</u> |
| 4. <u>B</u> | 8. <u>K</u> | 12. <u>I</u> |

REPORT OF THE BOARD

1999

The Board of Directors of the Corporation has reviewed the financial statements of the Corporation for the year ended December 31, 1999, and has approved the same for release to the stockholders of the Corporation. The financial statements have been audited by the independent accountants, who have issued their report thereon. The Board of Directors has also reviewed the report of the independent accountants and has approved the same for release to the stockholders of the Corporation.

2000

The Board of Directors of the Corporation has reviewed the financial statements of the Corporation for the year ended December 31, 2000, and has approved the same for release to the stockholders of the Corporation. The financial statements have been audited by the independent accountants, who have issued their report thereon. The Board of Directors has also reviewed the report of the independent accountants and has approved the same for release to the stockholders of the Corporation.





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Instructor's Manual
AC CONCEPTS & CIRCUITS
PARTS G1 to G5

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PARTS G1 to G5

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Ed-Lab Instructor's Manual for Concepts & Circuits PART 1 of 2

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ANSWERS - G1 SAFETY LESSON/INFORMATION SHEET 1

SAFETY LESSON

ASSIGNMENT

1. a Turn off power and remove victim.
b Loop a jacket or shop apron around the victim and pull him/her off the voltage source.
2. a Electrical Shock.
b Electrical Fire.
c Hand Tool Injury.
3. a 6
b 8
c 7
d 1
e 3
f 1, 4, 5
g 2
h 4
4. a F
b T
c F
d F
e T

INFORMATION SHEET 1 - CONCEPTS OF AC

ASSIGNMENT

1. T
2. F Dc power distribution systems are not used because dc cannot be stepped up and down using transformers.
3. T
4. T
5. T
6. F Transformers cannot be used on dc, only ac power.
7. T
8. T
9. T
10. F The time for an ac wave to complete one cycle is the PERIOD. Frequency is the number of cycles completed in one second.
11. T
12. F Generators used for power systems are usually rotary magnetic units driven by water power, steam power or some other motive force.
13. F A capacitor blocks dc but passes ac.
14. T
15. F Any voltage that reverses polarity and direction of current flow is an ac regardless of the waveshape.

ANSWERS - G1 EXPERIMENT NO. 1

EXPERIMENT NO. 1 - OBSERVING EFFECT OF AC VOLTAGES

PROCEDURE

3. The lamp is blinking on and off at a 1 Hertz rate.
4. Yes. 20 pulses per second or at a 10 Hz rate.
6. 38 Hz.
7.
 - No. Sixty Hertz is higher than the flicker rate, 38 Hz.
 - No. Because flicker stopped at 38 Hz which is lower than the 50 Hz power line.
 - Yes. There would be a problem with flicker in the lighting system.
9.
 - On the positive half of the cycle the meter pointer rises up to approximately 3 volts, swings back to zero and then goes below zero in a negative direction. This occurs once per second.
 - Yes. The meter could indicate the highest positive or negative voltage swing and allow an approximation of frequency by timing the pointer swing.
11.
 - The pointer vibrates with increased rapidity and its excursions above and below zero become shorter until, at approximately 30 Hz, there is no visible movement.
 - The dc meter would be useless above 10 Hz.
 - The time required for the pointer to move up-scale is much greater than the time duration of a half cycle of the ac. As a result, the meter pointer does not move at all.
13. A low pitch tone or buzz.
14. Yes.
15. 20 Hz -Typical, but will vary from person to person..
16. 10 kHz (typical).
17. 20 kHz -Typical, but will vary from person to person.
19. Yes.
21. No.
22. Zero volts.
23. A hum or buzz at a 60 Hz rate.

ASSIGNMENT

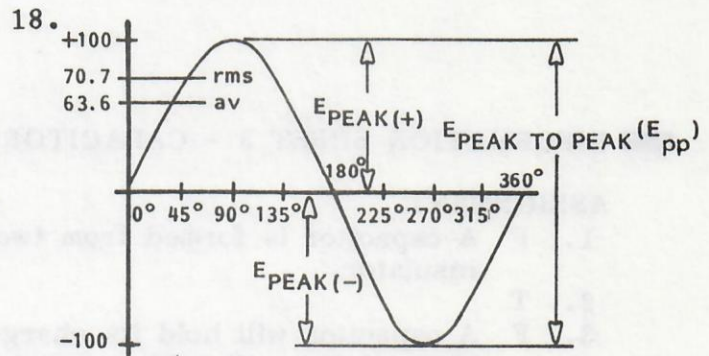
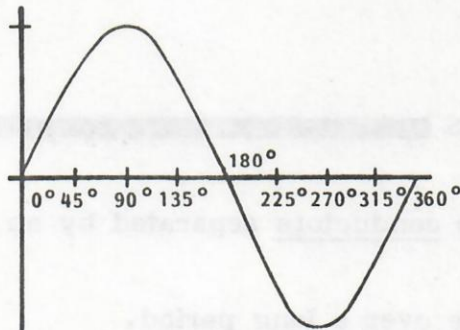
1. T
2. F Flicker starts to become apparent at lower frequencies approximately 30 to 38 Hz.
3. F Above approximately 20 Hz the meter pointer no longer moves and stays at zero.
4. T.
5. F The response of the average person to sound frequencies is from 20 Hz to 20 kHz.

ANSWERS - G1 INFORMATION SHEET 2/EXPERIMENT NO. 2

INFORMATION SHEET 2 - ALTERNATING CURRENT AND VOLTAGE

ASSIGNMENT

1. T
2. T
3. T
4. F The ac generator uses slip rings and the dc generator uses a commutator.
5. F The output of an ac generator is called a sine wave because it varies at a sine rate.
6. T
7. T
8. F A sine wave with a 2 mS period has a frequency of 500 Hz.
 $f = 1/T = 1/2 \times 10^{-3} = \underline{500 \text{ Hz}}$
9. F The positive and negative peaks of a sine wave are always equal. Thus $E_{pp} = 2 E_p$.
10. T $T = 1/f = 1/25,000 = 0.00004 \text{ S} = \underline{0.04 \text{ mS}}$
11. F A frequency of 750,000 Hz can be represented as 0.75 MHz. or 750 kHz.
12. T $E_p = (\text{rms})(1.414) = (140)(1.414) = \underline{197.96 \text{ V}}$
13. F A sine wave with a p-p of 220 volts has an rms of 77.77 V.
 $E_p = E_{pp} / 2 = 220/2 = 110$
 $E_{\text{rms}} = E_p \times 0.707 = \underline{77.77 \text{ V}}$
14. F The average voltage of a complete sine wave is zero since the positive and negative peaks, being identical, cancel each other.
15. T $250/2 = 125 \text{ V}_p$ $125 \times 0.707 = \underline{88.4 \text{ V}}$
16. T
- 17.



EXPERIMENT NO. 2 - MEASURING AC VOLTAGES

PROCEDURE

2. 20 V_{ac}.
3. $T_R = 120/V_s = 120/\underline{20}$ $T_R = \underline{6:1}$
4. 10 V_{ac}.

ANSWERS - G1 EXPERIMENT NO. 2 (CONT.)/INFORMATION SHEET 3

EXPERIMENT NO. 2 (CONT.) - MEASURING AC VOLTAGES

8. Yes.
11. 4.75 Vrms (typical).
13. Yes.
16. 2.06 Vac.
17. 2 Vac.
18. •No, the output voltage remains constant at 2 volts.
•There is no difference in behavior between dc and ac in a resistive circuit.
19. Answers will vary with selection of meter.
20. Answers will vary with selection of meter.
21. Answers will vary with selection of meter.

ASSIGNMENT

1. d none of the above.
2. c diodes must be added to the meter circuit.
3. b 25 volts.
4. a 50 volts.
5. b slightly more than 200 volts.
6. d all of the above. $60 \text{ Vdc} = 60 \text{ Vrms}$. $60 \times 1.414 = 84.84 \text{ V pk}$
7. c 30 volts. $V_o = (V_s)R_2/R_1+R_2 = (90) 5/5+10 = \underline{30 \text{ V}}$
8. d all of the above. $50 \text{ Vdc} = 50 \text{ Vrms}$. $50 \times 1.414 = 70.7 \text{ pk}$.
 $70.7 \text{ pk} \times 2 = 141.4 \text{ pp}$.
9. b 1 kHz.
10. a may be calculated using Ohm's Law.

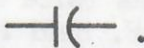
INFORMATION SHEET 3 - CAPACITORS

ASSIGNMENT

1. F A capacitor is formed from two conductors separated by an insulator.
2. T
3. F A capacitor will hold its charge over a long period.
Electrolytics will hold a charge but dissipate it sooner than micas or papers.
4. T
5. T
6. F The valence electrons of the dielectric atoms go into a distorted elliptical orbit but do not break loose.
7. T
8. T
9. F The Farad is not a practical unit because it is too large. Thus the prefixes must be fractional such as a micro and pico.
10. T
11. F The charge on a capacitor is equal to $Q = CV$.
12. T

ANSWERS G1 - INFORMATION SHEET 3 (CONT)

INFORMATION SHEET 3 - CAPACITORS (CONT)

13. T
14. F The higher the dielectric constant, k , the greater the capacitance it will produce. Recall that $C = kA/d$.
15. T
16. F The greater the charging voltage and the greater the capacitance, the greater the energy stored (in joules) because $\mathcal{E} = 1/2 CV^2$.
17. T
18. T
19. T
20. F The rating is equal to the lowest rating in the parallel group.
21. T
22. $0.00005 \text{ F} = 50 \mu\text{F}$. $C = \frac{i}{\frac{v}{t}} = \frac{0.001}{\frac{2}{0.1}}$ $C = \underline{0.00005 \text{ F} = 50 \mu\text{F}}$.
23. a $Q = 2 \times 10^{-3} \text{ coulombs}$. $Q = CV$
 $= (20 \times 10^{-6})(100)$
 $= 2000 \times 10^{-6} = \underline{2 \times 10^{-3} \text{ coulombs}}$
b $Ne = 12.5 \times 10^{15} \text{ electrons}$. $Ne = Q (6.25 \times 10^{18})$
 $= (2 \times 10^{-3})(6.25 \times 10^{18})$
 $= \underline{12.5 \times 10^{15} \text{ electrons}}$
24. $0.0225 \mu\text{F}$. $C = \frac{Ak}{d} (0.2249) = \frac{(50)(40)}{0.02} (0.2249)$
 $C = 22490 \text{ pF} \approx \underline{0.0225 \mu\text{F}}$.
25. a $84 \mu\text{F}/10 \text{ WV}$ $C_T = C_1 + C_2 + C_3 = 50 + 22 + 12 = \underline{84 \mu\text{F}}$.
 $\text{WV} = 10 \text{ V}$, the lowest rating.
b $25 \mu\text{F}/20 \text{ WV}$ $C_T = \frac{(C_1)(C_2)}{C_1 + C_2} = \frac{(50)(50)}{50 + 50}$
 $C_T = \frac{2500}{100} = 25 \mu\text{F} = \text{WV } 2 \times 10 = \underline{20 \text{ V}}$
26. a Electrostatic lines of force are said to run from positive to negative.
27. b The symbol for a capacitor is .
28. c A capacitor can store energy in its dielectric.
29. c When a capacitor is charged, the dielectric atom's electron orbits are distorted.
30. d All of the above.
31. c $5 \mu\text{F} \times 10^6 = \text{pF} = 5 \times 10^6 = 5,000,000 \text{ pF}$.
32. b Capacity increases when the capacitor plates are moved closer together.
33. c A capacitor is designed with a mica dielectric with a thickness of 0.0001 inches. If the mica is replaced with the same thickness plastic, Neoprene, the effect will be to increase the capacitance but reduce the voltage rating.
See Tables 1 and 2 in the Discussion.

ANSWERS - G1 INFORMATION SHEET 3 (CONT)/EXPERIMENT NO. 3

INFORMATION SHEET 3 - CAPACITORS (CONT)

34. a A 50 μF and 100 μF are wired in series. The capacitance will be equal to 33.3 μF .

$$C_T = \frac{(C1)(C2)}{C1 + C2} = \frac{(50)(100)}{50 + 100} \quad C_T = \frac{5000}{150} = \underline{33.333 \mu\text{F}}$$

35. b A 50 μF and 100 μF capacitor are wired in series across 150 volts. The voltage will divide between the capacitors with more across the 50 μF and less across the 100 μF .

36. d 10 μF /30 V.

10 and 20 μF in parallel $C_T = 10 + 20 = 30 \mu\text{F}$

$$C_T = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}} = \frac{1}{\frac{1}{30} + \frac{1}{30} + \frac{1}{30}} \quad C_T = \frac{1}{0.1} = \underline{10 \mu\text{F}}$$

$$\text{WV} = 10 + (10 \parallel 20) + 10 \quad \text{WV} = 10 + 10 + 10 = \underline{30 \text{ V.}}$$

37. a Red = 2; Yellow = 4; Brown = 1 zero = 240 pF.

38. a The capacitor shown in (b) of Figure 19 is in the JAN code.

39. c Capacitor (c) in Figure 19 is ceramic and is rated at 0.003 μF /500 V.

40. d If the blank dot in capacitor (b) of Figure 19 was colored green, it would mean whatever the manufacturer intended it to mean.

EXPERIMENT NO. 3 - CAPACITOR ACTION

PROCEDURE

3. The lamp flashed briefly as the capacitor discharged through the lamp.
5. •The lamp flash was twice as bright as in step 3 because the new capacitance, 200 μF , held twice the charge of a 100 μF capacitor.
•200 μF .
7. •Lamp 1 did not glow because the charge held by the series 100 μF capacitors was not great enough.
•50 μF .
9. The meter pointer swings up-scale to 8.5 volts and then drops slowly back to zero.
10. $Q = 0.0009 \text{ coulombs}$
 $(100 \times 10^{-6}) (9^2)$
11. • $\mathcal{E} = \frac{\quad}{2} = \underline{0.00045 \text{ joules}}$
•No. At least 1 joule is needed for a shock.
13. 24 seconds.
15. Yes. The measured time was 24 seconds.
17. 8.5 V (typical).

ANSWERS G1 - EXPERIMENT NO. 3 (CONT)

EXPERIMENT NO. 3 - CAPACITOR ACTION (CONT)

18. LEFT (typical).

19. 1.5 m

20. ●8.5 V

●Yes.

●Several hours.

●Yes. Capacitors should not be left with a charge. They should be discharged to prevent a shock hazard.

22.

SWITCH (UP or DOWN)	INPUT (AC or DC)	LAMP (ON or OFF)
UP	DC	OFF
DOWN	AC	ON

TABLE 1

23. ●Yes.

●No.

●No.

●Yes.

25.

CAPACITOR	LAMP INTENSITY
2 μ F	OFF
5 μ F	DIM
10 μ F	MEDIUM
100 μ F	VERY BRIGHT

TABLE 2 - Lamp intensity.

●The lower the capacitance the greater the reactance, an inverse relationship.

27. $E_R = 0.7$ V

28. $E_C = 9.5$ V

29. ● $I = \frac{(0.7)}{100} = 0.007$ A

$X_C = \frac{(9.5)}{(0.007)} = 1357$ ohms

32. The meter pointer swings to the right, almost to zero, and then the resistance increases gradually. In 60 seconds the pointer is almost at infinity, the extreme left.

ANSWERS G1 - EXPERIMENT NO. 3 (CONT)

EXPERIMENT NO. 3 - CAPACITOR ACTION (CONT)

33.

CAPACITOR	POINTER SWING
a. 10 μ F	THREE QUARTERS DEFLECTION
b. 5 μ F	TWO THIRDS DEFLECTION
c. 1 μ F	ONE THIRD DEFLECTION
d. 0.25 μ F	ONE TENTH DEFLECTION
e. 0.01 μ F	SLIGHT DEFLECTION
f. 330 pF	NO DEFLECTION

TABLE 3 - Capacitor deflection.

•The greater the capacity the greater the charging current and the further towards zero ohms the pointer will swing.

34. Answers will vary with capacitor selection.

ASSIGNMENT

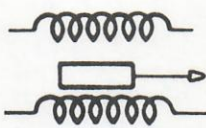
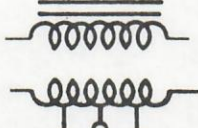
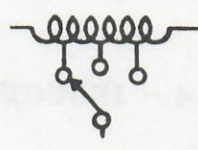
- b A capacitor is formed by two conductors separated by an insulator.
- a The charge on a capacitor can be calculated using the formula $Q = CV$.
- d $Q = CV = (470 \times 10^{-6})(50) = 0.0235$
 $Ne = (Q)(6.25 \times 10^{18}) = (0.0235)(6.25 \times 10^{18})$
 $Ne = 1.469 \times 10^{17} = 14.69 \times 10^{16}$
- c The energy stored in a capacitor is measured in joules.
- c In order to discharge a capacitor an external path between the plates must be provided.
- d A capacitor, when wired into a circuit, will block dc and pass ac.
- c When testing a 250 pF capacitor with an analog ohmmeter on the $\times 1000$ scale, it is normal for the meter pointer to barely move, if at all.
- d All of the above.
- c $C_T = C_1 + C_2 = 50 + 50 = 100 \mu F$.
- a $\mathcal{E} = 1/2 CV^2 = 1/2 (50 \times 10^{-6})(30)^2$
 $= 0.045/2 = 0.0225 \text{ joules}$
- d All of the above.
- a $T = RC = (1 \times 10^6)(0.5 \times 10^{-6}) = 0.5 \text{ seconds}$

ANSWERS G2 - INFORMATION SHEET 4

INFORMATION SHEET 4 - INDUCTORS

ASSIGNMENT

1. F Inductance is the ability of a component to oppose any change in the current flowing through it.
2. T
3. T
4. T
5. T
6. T
7. F $2000 \text{ mH} = 2,000 \times 10^{-3} \text{ H} = \underline{2\text{H}}$
8. F $e_{\text{ind}} = L \times \Delta i / \Delta t = 50 \times 10^{-3} \times 20 = \underline{1\text{V}}$
9. F Decreasing delta t increases the induced voltage. See equation (3).
10. T
11. F It is equal to 0.00156 joules not henries.

$$\mathcal{E} = \frac{1}{2} LI^2 = \frac{(50 \times 10^{-3})(0.25)^2}{2} = \underline{0.00156 \text{ J}}$$
12. T
13. F Increasing coil length decreases L. See equations (5), (6) and (7).
14. T
15. T
16. F The cores for high frequency coils are made of powdered iron or ferrite. Laminated cores are used for large value inductors for low frequency applications.
17. T
18. F The lower the core dc resistance the more efficient it is.
19. T
20. F Parallel inductors behave like parallel resistors. The total inductance is less than the lowest value inductor.
21. T
22. F The coefficient of coupling will be approximately equal to zero.
23. F They are said to be tightly coupled.
24. T
25. T
26. a.  b. 
c.  d. 
27. A = 1; B = 2; C = 3; D = 2; E = 2.

ANSWERS G2 - INFORMATION SHEET 4 (CONT)/EXPERIMENT NO. 4

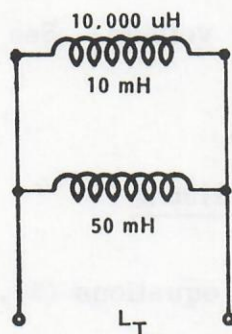
INFORMATION SHEET 4 - INDUCTORS (CONT)

$$28. \quad a \quad L = \frac{N^2 R^2}{9R + 10 \ell} = \frac{(60^2)(1^2)}{(9)(1) + (10)(10)}$$

$$= \frac{3600}{9 + 100} = \frac{3600}{109} = 33 \mu H$$

$$b \quad L = \frac{N^2 \mu R^2}{9R + 10 \ell} = \frac{3600 \times 5}{109} = 165 \mu H$$

29. a



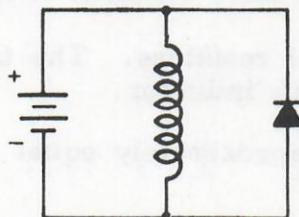
$$L_T = \frac{(L_1)(L_2)}{L_1 + L_2} = \frac{(10)(50)}{(10) + (50)} = \frac{500}{60} = 8.3 \text{ mH}$$

b



$$L_T = L_1 + L_2 = 10 + 50 = 60 \text{ mH}$$

30.



EXPERIMENT NO. 4 - INDUCTOR ACTION

PROCEDURE

4. The LED blinks briefly each time SA is closed because the inductor opposes the current flow initially so all the current flows through the LED, at first.
7. The LED flashes each time SA is opened, indicating the generation of a voltage opposite in polarity to the applied voltage, created by the shrinking magnetic field.
9. Lamp 2 lights at almost full intensity because the inductor does not oppose dc.

ANSWERS - G2 EXPERIMENT NO. 4 (CONT)/INFORMATION SHEET 5

EXPERIMENT NO. 4 - INDUCTOR ACTION (CONT)

10. The lamp glows very dimly (or not at all) due to the high opposition to ac displayed by the inductor.
11. With Switch SB down, Lamp 2 lights at full intensity because the inductor has been shorted out and is no longer in series with the lamp.
13. $E_{Rac} = 2.1 \text{ V}$
14. $E_{Lac} = 7.5 \text{ V}$
15. $I_{ac} = \frac{E_{Rac}}{R} = \frac{(2.1)}{100} = \underline{0.021 \text{ A}}$
16. ●AC Resistance $X_L = \frac{(7.5)}{(0.021)} = \underline{357 \Omega}$
●The inductive reactance is much larger than the dc resistance.

ASSIGNMENT

1. d all of the above.
2. c magnetic field strength increases.
3. d all of the above.
4. c add turns to the inductor.
5. d all of the above.
6. b shrinks to generate an inductive kick opposite in polarity to the voltage that created the field.
7. a inductive reactance.
8. c 4 H. $L_T = \frac{L_1 + L_2}{L_1 + L_2} = \frac{(5) (20)}{5 + 20} = \underline{4 \text{ H}}$
9. c 50 mH. L decreases by the square. $(200 \text{ mH})(0.5^2)$.
10. b light every half cycle but appear to be on continuously.

INFORMATION SHEET 5 - TRANSFORMERS

ASSIGNMENT

1. T
2. T
3. F Power is delivered to the load by the secondary winding.
4. T
5. T
6. F It will deliver $E_p \times 5$ or $200 \times 5 = 1000$ volts from the secondary.
7. T $E_s = TR \times E_{pri} = 0.25 \times 120 = \underline{30 \text{ V}}$.
8. F $E_p = 75 \text{ V}$.
 $E_p = E_s \frac{N_p}{N_s} = (300) \frac{150}{600} = \underline{75 \text{ V}}$
9. F The polarities for the instant shown are: A-; B+; C+; D1.

ANSWERS G2 - INFORMATION SHEET 5 (CONT)/EXPERIMENT NO. 5

INFORMATION SHEET 5 - TRANSFORMERS (CONT)

10. T
11. T
12. F The transformer core gets hotter due to an increase in I^2R losses.
13. F Hysteresis losses are due to the power needed to realign the magnetic dipoles in the core.
14. F Eddy currents are minimized by the use of laminated cores.
15. T
16. T
17. T
18. T
19. 144 V.

$$E_S = E_P \times T_R = 120 \frac{600}{500} = (120)(1.2) = \underline{144 \text{ V}}$$
20. 120 V.

$$E_P = E_S \frac{N_P}{N_S} = 30 \frac{500}{125} = (30)(4) = \underline{120 \text{ V}}$$

EXPERIMENT NO. 5 - TRANSFORMER ACTION

PROCEDURE

3. ●DIGITAL. (typical)
 ● $e_p = 9.2 \text{ V}$; $e_s = 36.1 \text{ V}$.
 ●Step up.
4. $T_R = \frac{(36.1)}{(9.2)} = \underline{3.9:1}$ Step up
6. $e_p = \underline{9.96 \text{ V}}$; $e_s = \underline{2.49 \text{ V}}$.
7. $T_R = \frac{(9.96)}{(2.49)} = \underline{4:1}$ Step Down
8. 120 V to 24 V.
10. $e_p = \underline{19.74 \text{ V}}$; $e_s = \underline{4.99 \text{ V}}$; $e_{RA} = \underline{0.249 \text{ V}}$.
11. $I_P = \frac{(0.249)}{(100)} = 0.00249 \text{ A}$
12. $P_{IN} = (19.74)(0.00249) = 0.049 \text{ W}$.
13. $e_p = \underline{18.00 \text{ V}}$; $e_s = \underline{3.54 \text{ V}}$; $e_{RA} = \underline{1.035 \text{ V}}$.
14. $i_p = \frac{(1.035)}{(100)} = 0.01035 \text{ A}$
15. ● $P_P = (18)(0.01035)$
 INPUT POWER $P_{IN} = \underline{0.186 \text{ W}}$ or 186 mW.
 ● $P_S = \frac{(3.5)^2}{(100)}$
 OUTPUT POWER $P_{OUT} = \underline{0.1225 \text{ W}}$ or 122.5 mW.

ANSWERS G2 - EXPERIMENT NO. 5 (CONT)/EXPERIMENT NO. 6

EXPERIMENT NO 5. (CONT)

16. $P_{\text{Loss}} = (186) - (122.5) = 63.5 \text{ mW.}$

- 1. $I^2 R$ losses.
- 2. Hysteresis losses.
- 3. Eddy current losses.

17. $\% \text{Eff} = \frac{(122.5)}{(186)} \times 100 = 65.9\%$

18. $e_T = 3.51 \text{ V}; e_a = 1.76 \text{ V}; e_b = 1.762 \text{ V.}$

20. $e_{\text{in}} = 15.15 \text{ V}; e_{\text{out}} = 30 \text{ V.}$

21. $T_R = \frac{(30)}{(15.15)} = 1.99:1 \text{ Step up}$

ASSIGNMENT

1. F The turns-ratio is 1.5:1 but the transformer is a step up from 32 to 48 volts.
2. T
3. T
4. F The ideal transformer cannot be built. There is always resistance in the windings and loss in the core.
5. T
6. F Taps may be located anywhere between the two ends of the winding as required by a circuit design.
7. T

8. T $\text{Eff} = \frac{P_{\text{OUT}}}{P_{\text{IN}}} \times 100 \quad P_{\text{OUT}} = \frac{P_{\text{IN}} \times \text{Eff}}{100}$

$$P_{\text{OUT}} = \frac{20 \times 80}{100} = \frac{1600}{100} = 16 \text{ Watts.}$$

9. T

10. T $\frac{N_p}{N_s} = \frac{e_p}{e_s} \quad \frac{720}{N_s} = \frac{120}{30}$
 $\frac{720}{N_s} = 4 \quad N_s = \frac{720}{4} = 180 \text{ T}$

EXPERIMENT NO. 6 - DIODE ACTION

PROCEDURE

2. •Yes.
- Yes.
3. •No.
- Because D2 is wired so that it is reverse biased.

ANSWERS G2 - EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - DIODE ACTION (CONT)

SW A	DIODE	LAMP (ON-OFF)	BIAS (FWD-REV)
UP	D1	ON	FWD
DOWN	D2	OFF	REV

TABLE 1 - Diode states.

•Positive.

5.

SWITCH A	LAMP INTENSITY
UP	FULL INTENSITY
DOWN	HALF INTENSITY

TABLE 2 - Lamp intensity.

•The lamp is energized with the full Esecondary when SA is UP. When SA is DOWN, the diode conducts and energizes the lamp on the positive half cycles only and the lamp is off for the negative half cycles.

•Nothing. The lamp would light at the same intensity with SA DOWN because the negative half cycles produce the same voltage as do the positive half cycles.

7.

SWITCH SA	DIODE	METER READING
UP	NONE	0 V
DOWN	SERIES	4.2 V

TABLE 3 - Dc meter readings with and without diode.

•Yes.

8. $V_{ac} = 10 \text{ volts rms.}$

9. $V_{average} = (10)(0.45) = 4.5 \text{ V.}$

10. $V_{peak} = (10)(1.414) = 14.14 \text{ V.}$

12. • $V_{average} = 4.46 \text{ V.}$

•Very close.

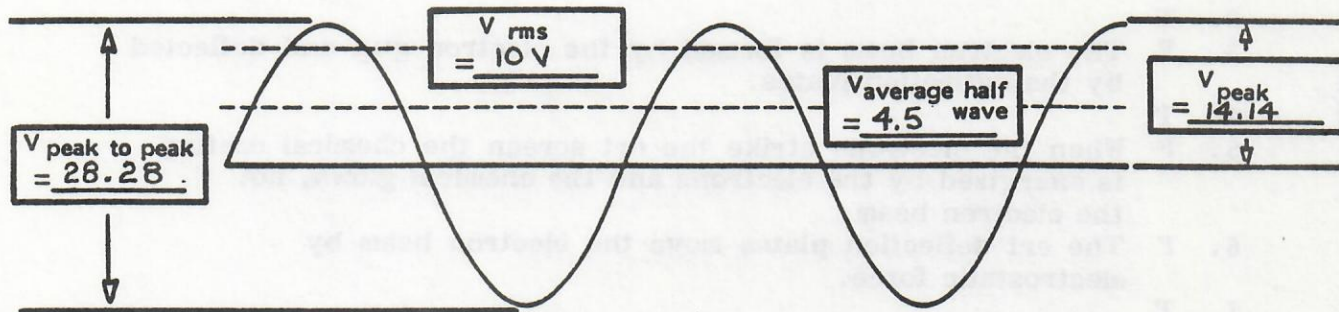
13. • $V_{peak} = 14.18 \text{ V.}$

•Very close.

ANSWERS G2 - EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - DIODE ACTION (CONT)

16.



ASSIGNMENT

1. d all of the above.
2. a A is the anode and B is the cathode (+).
3. c Reverse; do not flow.
4. b conduct from B to A.
5. a zero volts.
6. d 5.4 volts dc, average.
7. b 17 volts peak dc.
8. a directly in rms values in position 3 of SA.
9. c 0 to 20 volts dc.
10. d all of the above.

ANSWERS G3 - INFORMATION SHEET 1/EXPERIMENT NO. 1

INFORMATION SHEET 1 - OSCILLOSCOPE OPERATION

ASSIGNMENT

1. T
2. T
3. F The electron beam is formed by the electron gun and deflected by the deflection plates.
4. T
5. F When the electrons strike the crt screen the chemical coating is energized by the electrons and the chemical glows, not the electron beam.
6. F The crt deflection plates move the electron beam by electrostatic force.
7. T
8. F The electron gun is not movable. The beam is positioned by the two sets of deflection plates.
9. T
10. T
11. T
12. F The horizontal sweep is calibrated in TIME/DIV.
13. F The vertical sweep is calibrated in VOLTS/DIV.
14. T
15. T
16. F The function of the x5 Magnifier is to expand the display so that instead of five cycles appearing on the screen only one will.
17. F A dual trace scope does not require a crt with two electron guns. It provides two traces by sharing in either the Chop or Alternate modes.
18. T
19. T
20. T

EXPERIMENT NO. 1 - WAVEFORM OBSERVATIONS

PROCEDURE

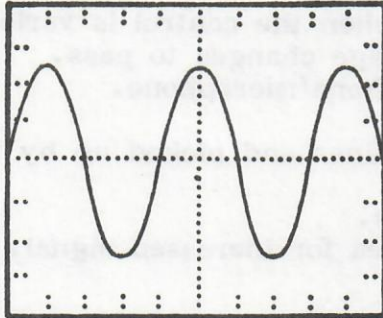
1. ●Intensity
Time/Div
Position ↑
Ac GND Dc
Source
Level
●CES
4708
●22
●3
●1. Channel 1; 2. Channel 2; 3. External Trigger

ANSWERS G3 - EXPERIMENT NO. 1 (CONT)

EXPERIMENT NO. 1 - WAVEFORM OBSERVATIONS (CONT)

4. Yes.

8.

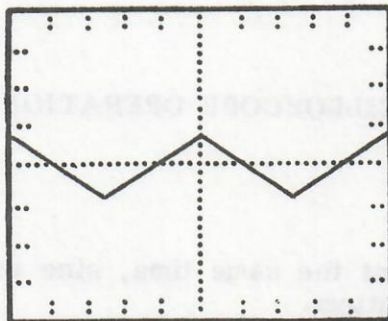


9.

FREQ. (kHz)	NO. OF CYCLES
1	1
2	3
3	3 1/2
4	4
5	5
6	6
7	7 1/2
8	8 1/4
9	9 1/4
10	10 1/4

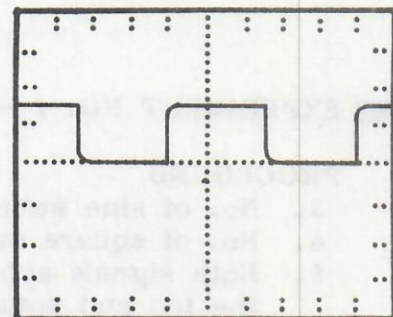
TABLE 1 - Input frequency versus screen display.

10. After 3/8" rotation in either direction the waveform changes to multiple sine waves that overlap and drift to the right of the screen.
11. When rotated from 0.2 to 10 mS the number of cycles appearing increases. At 10 mS the pattern flows across the screen in bursts.
13. The number of cycles displayed on the screen decrease until, at 2 mS we see what appears to be about 1/8 of the cycle, approximately.
15. The amplitude of the signal displayed on the screen increases. At the 1 V/DIV the trace runs off the top and bottom. At 0.2 V/DIV the trace is very light because it is spread so far out.
- 17.



TRIANGULAR WAVE

19.



SQUARE WAVE

21. 2 mS.

22. 5 mS.

ANSWERS G3 - EXPERIMENT NO. 1 (CONT)/EXPERIMENT NO. 2

EXPERIMENT NO. 1 - WAVEFORM OBSERVATIONS (CONT)

24. At zero volts the scope trace is at the center of the screen, zero V. Increasing +V1 moves the trace up 1.8 boxes or divisions on the screen, or 9 volts.
25. The trace on the screen moves only when the control is varied because the capacitor allows only voltage changes to pass.
28. Sound is converted to ac by the earphone/microphone.
30. ●Yes.
●It is 60 Hz radiated from the power lines and picked up by the loose lead.
31. ●The amplitude of the signal increases.
●The body acts as a large pick-up area for increased signal.

ASSIGNMENT

1. T
2. T
3. F In order to measure a dc voltage the Vertical Input switch must be set at DC.
4. F The probe switch should be set at x10 so that it presents 1/10 of the large input signal to the scope input.
5. F Banana leads can be used for almost all signal viewing.
6. T
7. F It is due to an improperly adjusted TRIGGER/LEVEL control.
8. F It is due to the VOLTS/DIV switch set improperly.
9. T
10. F Fewer cycles appear and if the TIME/DIV is made too small only a fraction of the waveform will appear.
11. F It is normally CH 1 INPUT, CH 2 INPUT and EXT SYNC.
12. T
13. F The number of cycles increase.
14. T
15. F It is no more difficult to observe nonsinusoidal waves than sine waves.

EXPERIMENT NO. 2 - DUAL TRACE OSCILLOSCOPE OPERATION

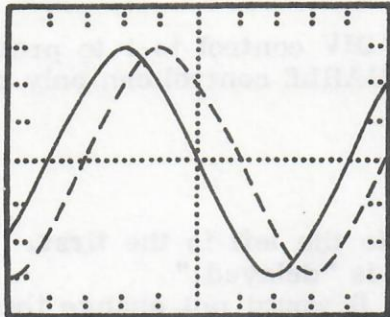
PROCEDURE

3. No. of sine waves = 5.
4. No. of square waves = 5.
5. Both signals appear on the screen at the same time, sine waves at the top and square waves at the bottom.
6. They are exactly the same frequency because they come from the same function generator.

ANSWERS - G3 EXPERIMENT NO.2 (CONT)

EXPERIMENT NO. 2 - DUAL TRACE OSCILLOSCOPE OPERATION (CONT)

13.



14. Angle = $(1)(45) = 45$ degrees

16. •Negative.

•No, it is positive going and has to be recentered.

17. Both sine and square waves now start the display with the negative half cycles.

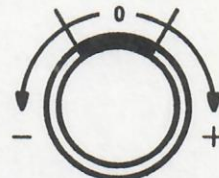
18. The trace drifts to one side of the screen, left or right.

19. Both traces lock in and cease to drift.

20.



(a)



(b)

Figure 6 - Sync range with external (a) and internal (b) sources; EXPERIMENT.

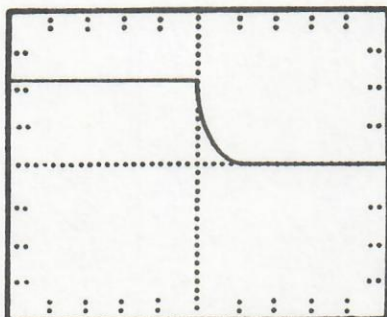
21. External trigger.

23. It is not synchronized and rolls.

24. The CH 2 input can be synchronized but the CH 1 signal rolls.

27. Both vertical traces.

28.



•Yes, but not too noticeable.

30. The ALT mode produces a visible flicker.

31. A series of "rolling" gaps appear in the sine wave display and, not as noticeable, also the square wave.

32. The gaps disappear and the screen presentation is now normal.

ANSWERS G3 - EXPERIMENT NO. 2 (CONT)/EXPERIMENT NO. 3

EXPERIMENT NO. 2 - DUAL TRACE OSCILLOSCOPE OPERATION (CONT)

ASSIGNMENT

1. F It is necessary to set the VOLTS/DIV control to 1 to provide more amplification because the VARIABLE control can only reduce the display amplitude.
2. T
3. T
4. T
5. F The signal that appears furthest to the left is the first. The signal that follows to its right is "delayed."
6. F Increasing the amplitude of signal B would not change the points at which it crosses over the zero lines and it is at the zero line where the measurement is made.
7. T
8. T
9. F One of the inputs can be synchronized as selected by the SYNC SOURCE which setting of CH 1 or CH 2.
10. F The MAGNIFIER control only expands the horizontal sweep, not the vertical.

EXPERIMENT NO. 3 - OSCILLOSCOPE MEASUREMENTS

PROCEDURE

4. Vertical Divisions = $\frac{6.4 \text{ DIV}}{1} = 6.4 \text{ DIV}$ (typical).
5. $V_{p-p} = (6.4)(2) = 12.8 \text{ V.}$
6. $V_{pk} = \frac{(12.8)}{2} = 6.4 \text{ V.}$
7. $V_{rms} = (6.4)(0.707) = 4.5 \text{ V.}$
8. ● $V_{rms} \text{ MEAS.} = 4.6 \text{ V.}$
● Very close.
9. $V_{ac} \text{ triangle wave} = 2.2 \text{ V.}$
10. $V_{p-p} \text{ triangle wave} = 6.4 \text{ V.}$
15. No. of divisions = 4.
16. Period(t) = $(4)(0.5 \text{ mS}) = 2 \text{ mS.}$
17. $f = \frac{1}{(.002)} = 500 \text{ Hz.}$
● Yes.
19. ● Counter reading 495 Hz (typical).
● Within 5 Hz.
22. ● Vertical divisions = 1.8 DIV.
● Up.
23. $V_{dc} = (1.8)(5) = 9 \text{ V.}$
24. The trace moves downward 1.8 boxes indicating a negative dc voltage.

ANSWERS G3 - EXPERIMENT NO. 3 (CONT)

EXPERIMENT NO. 3 - OSCILLOSCOPE MEASUREMENTS (CONT)

27. •Vertical divisions = 5.
 • $V_{pp} = (5)(0.1) = \underline{0.5 \text{ volts.}}$
 •Yes.
28. Yes.
29. Horizontal divisions = 2 DIV.
30. •Period = $(2)(0.5) = \underline{1 \text{ mS.}}$
 • $f = \frac{1}{(1 \times 10^{-3})} = \underline{1000 \text{ Hz}}$
31. No, a bit more (typical.)
33. •60 Hz divisions = 8.2 DIV.
 •Power line period = $(8.2)(2 \text{ mS}) = \underline{16.4 \text{ mS.}}$
 •Power line frequency = $\frac{1}{(16.4 \times 10^{-3} \text{ S})} = \frac{1}{(.0164)} = \underline{60.97 \text{ Hz.}}$
 •Very close. An error of only 0.97 Hz.
 •No. The error is due to the accuracy to which it is possible to read the divisions on the scope and the accuracy of the scope calibration.

ASSIGNMENT

1. b rms voltage.
2. a sine waves.
3. d 1 cm.
4. c $\frac{(\text{VOLTS/DIV})(\text{No. of Vert Div})(\text{Probe Setting})}{2}$
5. c CH 1 VARIABLES control to CAL.
6. a 0.136 V.
 $E_{p-p} = (\text{No. of Div})(V/DIV) = (6.8)(20 \text{ mV})$
 $= 136 \text{ mV} = 0.136 \text{ V}$
7. c 12 V. $E_{rms} = \frac{(\text{No. of Div})(V/DIV)(0.707)}{2} = \frac{(6.8)(5)(0.707)}{2}$
 $= \underline{12.019 \text{ V}}$
8. c 0.029 mS.
 Period = $(\text{No. of Div})(\text{TIME/DIV}) = (5.8)(5 \mu\text{S})$
 $= 29 \mu\text{S} = \underline{0.029 \text{ mS}}$
9. d 20,000 Hz.
 $f = \frac{1}{t} = \frac{1}{50 \times 10^{-6}} = 20,000 \text{ Hz} = \underline{20 \text{ kHz.}}$
10. d none of the above.
 $t = \frac{1}{f} = \frac{1}{2500} = \underline{0.0004 \text{ S}} = \underline{0.4 \text{ mS.}}$

ANSWERS G3 - EXPERIMENT NO. 4

EXPERIMENT NO. 4 - TIME CONSTANTS

PROCEDURE

5.

TIME (S)	VOLTS
0	0
5	2.83
10	4.83
20	7.0
30	8.0
40	8.51
50	8.73
60	8.84
70	8.89
80	8.92
90	8.93
100	8.94

6.

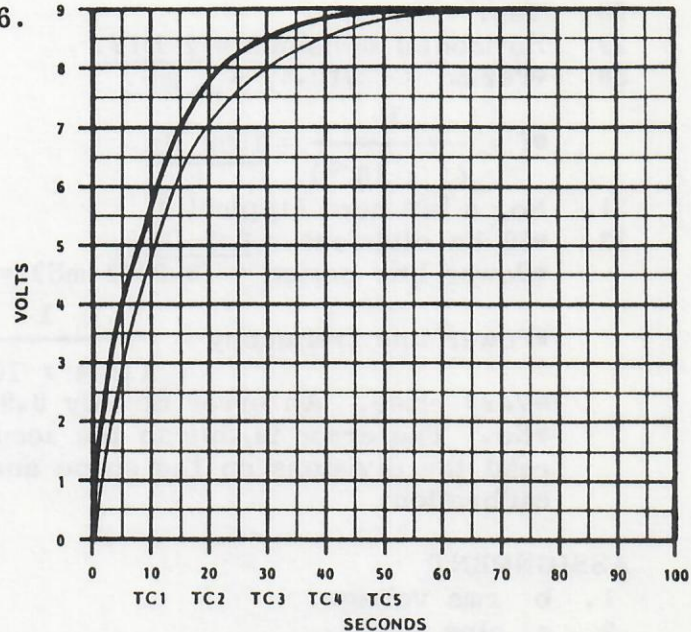


Figure 6 - Exponential curve.

TABLE 1 - Capacitor voltage versus time.

•Very close.

9.

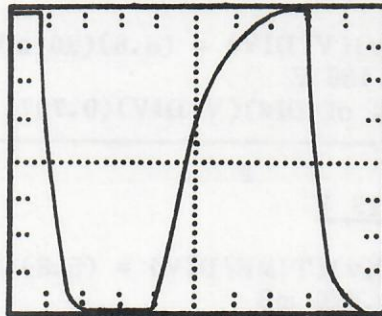


Figure 8 - Charge-discharge waveform for the capacitor in the circuit of Figure 7; EXPERIMENT.

12. $T_C = (2.2)(0.1) = 0.22 \text{ mS.}$

13. • $T = 0.22 \text{ mS.}$

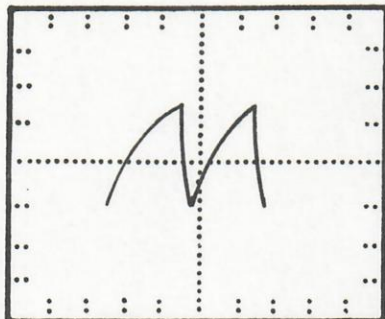
•Exactly the same.

15. With SA down, the frequency is high. With SA up, the frequency is lower. The 100 K pot varies the frequency in both the high and low range.

ANSWERS G3 - EXPERIMENT NO. 4 (CONT)/EXPERIMENT NO. 5

EXPERIMENT NO. 4 - TIME CONSTANTS (CONT)

16.



- It is the start or the lower portion of an exponential curve.
- 20. $T = (2.5)(0.02) = \underline{0.05 \text{ mS.}}$
- 21. • $T = \underline{0.06 \text{ mS.}}$
- Yes.
- Tolerance of components; oscilloscope calibration; technician error.

ASSIGNMENT

1. T
2. T
3. F $T = R C$
4. F The time constant is that time required for a capacitor to charge to 63.2% of the source voltage.
5. F A capacitor charges AND discharges at an exponential rate.
6. T $V_{TC1} = (V_{\text{source}})(63.2\%) = (100)(.632) = \underline{63.2 \text{ V.}}$
 $V_{TC2} = (100 - 63.2)(.632) + 63.2 \text{ V} = \underline{86.45 \text{ V.}}$
7. T $T = RC = (22 \times 10^3) \times (0.22 \times 10^{-6}) = \underline{4.8 \text{ mS.}}$
8. F A capacitor is considered to be fully charged after 5 time constants.
9. T $T = R C = (470 \times 10^3)(800 \times 10^{-12}) = \underline{0.376 \text{ mS.}}$
10. F $T = \frac{L}{R}$
11. T $T = \frac{L}{R} = \frac{3}{2000} \quad T = \underline{1.5 \text{ mS}}$
12. F $V_{\text{Div for 1 TC}} = (\text{TOTAL DIV})(0.632) = (6)(0.632) = \underline{3.792}$

EXPERIMENT NO. 5 - BH MAGNETIZATION CURVE

PROCEDURE

5. •Yes.
- Only the upper right, quadrant I.

ANSWERS G3 - EXPERIMENT NO. 5 (CONT)

EXPERIMENT NO. 5 - BH MAGNETIZATION CURVE (CONT)
10.

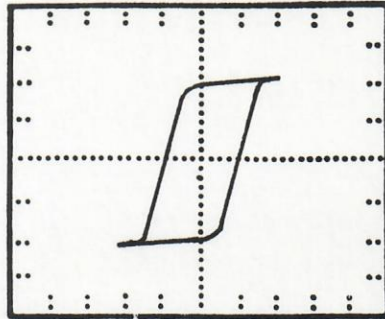


Figure 9 - Hysteresis loop displayed on the screen.

•Yes.

ASSIGNMENT

1. F While B is equal to H for an air core coil, air will not saturate.
2. T
3. T
4. F Increases in H, after saturation has been reached, will produce an increased B equal to the increase experiences in an air core coil.
5. F A core is saturated when every dipole in the core is aligned.
6. F The descending current will produce a different current through the inductor than the rising current due to rententivity. the effect is called hysteresis.
7. T
8. T
9. a. C
b. F
c. B, G
d. G To B or (B to G)
e. E
f. A
g. Y
h. X
i. W
j. Z

ANSWERS G3 - EXPERIMENT NO. 6

EXPERIMENT NO. 6 - EXTERNAL TEST EQUIPMENT

PROCEDURE

3.

RESISTOR	POINTS	VOLTAGES
LEFT 1K	A - B	<u>4</u> V
RIGHT 1K	B - C	<u>4</u> V

TABLE 1 - Voltage divider readings; 1 K resistors.

•Each voltage drop equals 1/2 of +V1, 8 volts because the resistors are of equal value.

5.

RESISTOR	POINTS	VOLTAGES
LEFT 470 K	A - B	<u>3.8</u> V
RIGHT 470 K	B - C	<u>3.8</u> V

TABLE 2 - Voltage divider readings; 470 K resistors.

•The voltage readings are lower due to meter loading but they are still equal and close to correct.

•The voltages will still be equal but much lower (2V) due to the increased meter loading.

8. •0-10 V.

•8 ranges (typical).

•10-100 Hz (typical).

9.

RESISTOR	POINTS		VOLTAGE
	GROUND LEAD	HOT LEAD	
RIGHT 1 K	C	B	<u>1.5</u> V
RIGHT 1 K	B	C	<u>1.55</u> V
LEFT 1 K	B	A	<u>1.4</u> V
LEFT 1 K	A	B	<u>1.7</u> V

TABLE 3 - Ac voltage readings for Figure 12.

•Only the voltage across the right hand 1 K could be measured accurately and only when the meter common was connected to ground. The FET multimeter is accurate only when the common lead is at ground potential.

10.

RESISTOR	POINTS		VOLTAGE
	GROUND LEAD	HOT LEAD	
RIGHT 470 K	C	B	<u>1.3</u> V
RIGHT 470 K	B	C	<u>3.8</u> V
LEFT 470 K	B	A	<u>5.4</u> V
LEFT 470 K	A	B	<u>1.6</u> V

TABLE 4 - Ac voltage readings with 470 K resistors.

•The voltage reading across the right hand 470 K resistor is lower than the expected 1.5 V due to meter loading in a high resistance circuit. All other readings are in error, in addition to loading, because the common lead is not at ground potential.

ANSWERS G3 - EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - EXTERNAL TEST EQUIPMENT (CONT)

13.

RESISTOR	POINTS		VOLTAGE
	GROUND LEAD	HOT LEAD	
RIGHT 0.01 μ F	C	B	<u>1.0</u> V
RIGHT 0.01 μ F	B	C	<u>2.7</u> V
LEFT 0.01 μ F	B	A	<u>2.65</u> V
LEFT 0.01 μ F	A	B	<u>1.1</u> V

TABLE 5 - Ac voltage readings with a capacitor divider.

•A correct reading is obtained across the right hand 0.01 capacitor when the meter common lead is connected directly to ground. When the common is moved off ground, the readings are wrong. The left hand capacitor voltage reading is almost correct when the meter common lead is connected to point B, as close to ground as possible.

15.

CAPACITOR	POINTS		VOLTAGE
	R JACK	Y JACK	
RIGHT 0.01 μ F	C	B	<u>1</u> V
RIGHT 0.01 μ F	B	C	<u>1</u> V
LEFT 0.01 μ F	B	A	<u>1</u> V
LEFT 0.01 μ F	A	B	<u>1</u> V

TABLE 6 - Ac voltage readings using Ed-Lab instruments.

•All voltage readings are the expected values, 1 volt, regardless of the meter connections.

17. $V_L = 1.9$ V.

18. $R_S = 1000 \frac{(3) - (1.9)}{(1.9)} = \underline{579 \text{ ohms}}$

20. $V_L = 2.7$ V.

21. $R_S = 1000 \frac{(3) - (2.7)}{(2.7)} = \underline{111 \text{ ohms}}$

•The lower source resistance is better because there is less internal voltage drop when the generator is loaded thus a higher output signal voltage.

22. Yes.

23. •It disappeared from the screen.

•The ground loop placed a short across the Function Generator output.

24. Yes.

27. $V_{ac} = 0.85$ V.

•The voltage reading dropped from 1 V to 0.85 V, a 15% loss.

ANSWERS G3 - EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - EXTERNAL TEST EQUIPMENT (CONT)

31. •Vertical divisions = 2.8
• $V_{Lp-p} = (2.8)(1) = \underline{2.8 \text{ V}}$
32. • $V_{Lrms} = \frac{(2.8)}{2} (0.707) = \underline{0.9898 \text{ V.}}$
- Yes.

ASSIGNMENT

1. b One side of a power line is grounded just before it enters a building in order to minimize voltage surges due to lightning strikes on the power line.
2. b The standard household wiring color code is Black - HOT; White - NEUTRAL; Green - GROUND.
3. c The blade connection shapes of a duplex outlet are: Wide Blade - NEUTRAL; Narrow Blade - HOT; Round Blade - Ground.
4. a The person drawn in Figure 23 can receive a possible lethal shock.
5. d The person drawn in Figure 23 can suffer "all of the above."
6. c Unintentional "ground loops" formed by connecting several pieces of equipment together, can affect the meter readings and create short circuits.
7. a The third wire ground should be removed, if necessary, from a power plug by using an adapter and not grounding the green wire.

ANSWERS G4 - EXPERIMENT NO. 1

EXPERIMENT NO. 1 - INDUCTIVE REACTANCE

PROCEDURE

3.

SET	MEASURE		CALCULATE		COMPARE
1	2	3	4	5	6
f (Hz)	V_L SA DOWN	V_R SA UP	$I_R = I_L$ (mA)	$X_L = \frac{V_L}{I_R}$ (K OHMS)	$X_L = 2\pi fL$ (K OHMS)
1,000	0.6	3.8	3.8	0.158	0.157
2,000	1.1	3.7	3.7	0.297	0.314
3,000	1.65	3.5	3.5	0.508	0.471
4,000	2.1	3.25	3.25	0.646	0.628
5,000	2.5	3.0	3.0	0.833	0.785
10,000	3.45	1.95	1.95	1.769	1.570

TABLE 1 - Data for the circuit of Figure 5.

7. •Yes, column 5 and 6 answers are very close.
•Meter reading error, inductance tolerance and generator calibration error.

8.

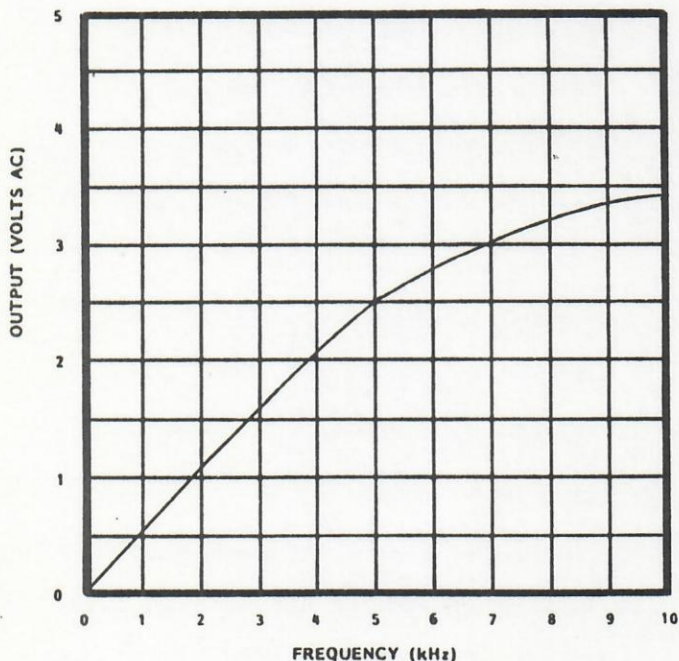


Figure 6 - Plot of V_{OUT} versus generator frequency.

10.

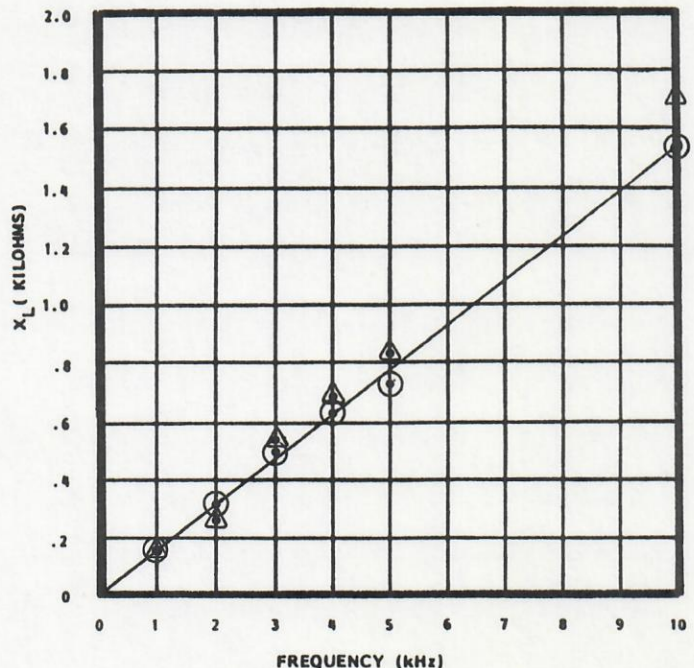


Figure 7 - Plot of theoretical reactance versus frequency.

11. Reasonably close at the lower frequencies.

ANSWERS G4 - EXPERIMENT NO. 1 (CONT)/EXPERIMENT NO. 2

EXPERIMENT NO. 1 - INDUCTIVE REACTANCE (CONT)

ASSIGNMENT

1. d all of the above.
2. c 251Ω

$$X_L = 2\pi fL = (6.28)(2 \times 10^3)(20 \times 10^{-3})$$

$$= (6.28)(2)(20) = 251.2 \Omega$$
3. b X_L varies directly with frequency.
4. a X_L is the opposition to the flow of ac, measured in ohms.
5. c as L is increased, its reactance, at a given frequency, increases.

EXPERIMENT NO. 2 - CAPACITIVE REACTANCE

PROCEDURE

3.

SET	MEASURE		CALCULATE		COMPARE
1	2	3	4	5	6
f	V_C	V_R	$I_R = I_C = \frac{V_R}{R}$	$X_C = \frac{V_C}{I_R}$	$X_C = \frac{1}{2\pi fC}$
(Hz)	SA DOWN	SA UP	(mA)	(K OHMS)	(K OHMS)
200	4.2	1.1	1.1	3.8	3.184
400	3.7	1.9	1.9	1.9	1.592
600	3.15	2.6	2.6	1.2	1.061
800	2.7	3.0	3.0	0.9	0.796
1000	2.3	3.2	3.2	0.7	0.637
1500	1.6	3.6	3.6	0.44	0.425
2000	1.3	3.8	3.8	0.34	0.318
2500	1.0	3.8	3.8	0.26	0.254
3000	0.9	3.9	3.9	0.23	0.212
3500	0.7	3.9	3.9	0.179	0.181
4000	0.6	3.9	3.9	0.154	0.159

TABLE 1 - Data for the RC network of Figure 4.

7. •Yes, column 5 and 6 are very close.
 •Instrument error, component tolerance and human error.

ANSWERS G4 - EXPERIMENT NO. 2 (CONT)

EXPERIMENT NO. 2 - CAPACITIVE REACTANCE (CONT)

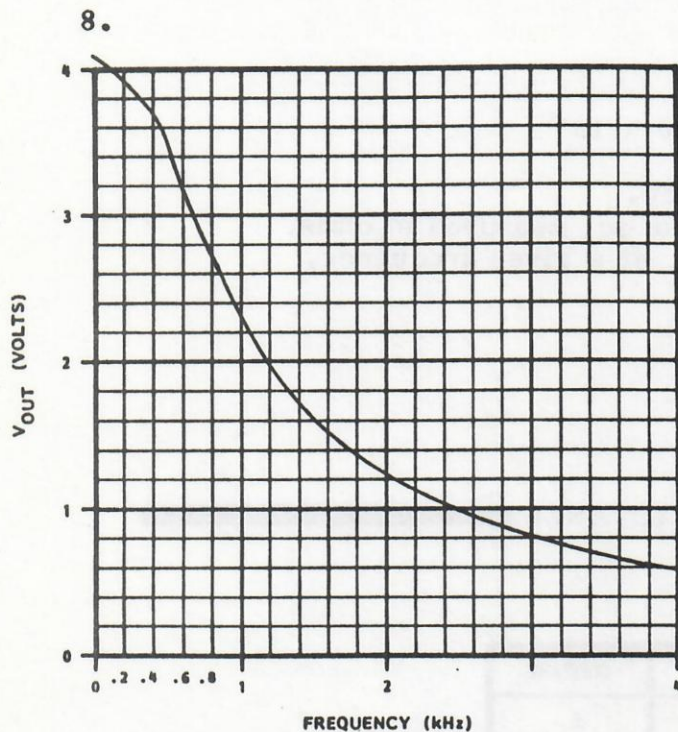


Figure 5 - Output voltage versus frequency.

10. Very close.

ASSIGNMENT

1. T

2. F The plot of X_C versus frequency is not a straight line because they have a reciprocal relationship. See Figures 2, 3 and 6 of this experiment.

3. T

4. T

5. T

$$I_R = \frac{V_R}{R} = \frac{1.2}{1 \text{ K}} = 1.2 \text{ mA} = I_C \quad X_C = \frac{V_C}{I_C} = \frac{2.4}{1.2} = 2 \text{ K}$$

6. F C and X_C are inversely related. As C increases X_C decreases.

7. T

$$X_C = \frac{1}{2\pi fC} = \frac{1}{(6.28)(5 \times 10^3)(0.05410^{-6})}$$

$$= \frac{10^3}{(6.28)(0.25)} = \underline{636.9 \Omega}$$

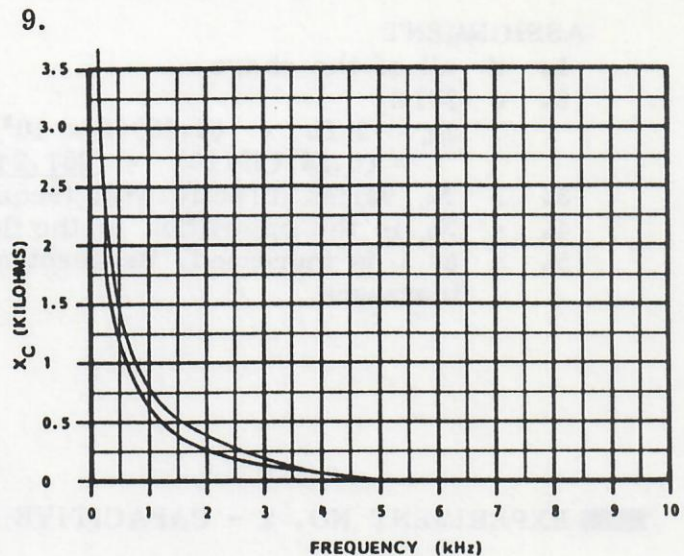


Figure 6 - Plot of theoretical and actual reactance versus frequency.

ANSWERS G4 - INFORMATION SHEET 1

INFORMATION SHEET 1 - AC VOLTAGES AND PHASORS

ASSIGNMENT

1. d all of the above.
2. d all of the above.
3. b hypotenuse is side c; altitude is side a.
4. b 48°
 $180^\circ = A + B + C = A + 90 + 42 = A + 132$
 $A = 180 - 132 = 48^\circ$
5. d $c = \sqrt{a^2 + b^2}$
6. a Signal A leads signal B by 45°.
7. d Signal B lags signal A by 90°.
8. a The phasor of Figure 21 represents R and L.
9. c $a = \sqrt{50^2 + 30^2} = 58.3$
10. d All of the above.
11. b V_R is the reference and V_C lags by 90°.
12. c $Z = \sqrt{R^2 + X_C^2} = \sqrt{6^2 + 8^2} = 10 \text{ K.}$
13. a $Z = 10 \text{ K; } V = 100 \text{ V; } I = \frac{V}{Z} = \frac{100}{10 \times 10^3} = 10 \text{ mA.}$
14. b $\theta = \arctan \frac{X_C}{R}$
15. a $\theta = \arctan \frac{X_C}{R} = \arctan \frac{20}{10} = \arctan 2 = 63.4^\circ$
16. b Theta decreases since $\theta = \arctan \frac{X_C}{R}$
17. c The net reactance in a series RLC circuit equals $(X_L - X_C)$ or $(X_C - X_L)$.
18. d 5 K
 $Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{3^2 + (10-6)^2} = \sqrt{3^2 + 4^2} = 5 \text{ K}$
19. a $\theta = \arctan \frac{X_C}{R} = \arctan \frac{10-6}{3} = \frac{4}{3} = 53.13^\circ \text{ leading}$
20. c 58.3 V
 $V_S = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{30^2 + (90 - 40)^2}$
 $= \sqrt{900 + 2500} = \sqrt{3400} = 58.3 \text{ V}$

ANSWERS G4 - EXPERIMENT NO. 3

EXPERIMENT NO. 3 - SERIES RC CIRCUITS

PROCEDURE

4.

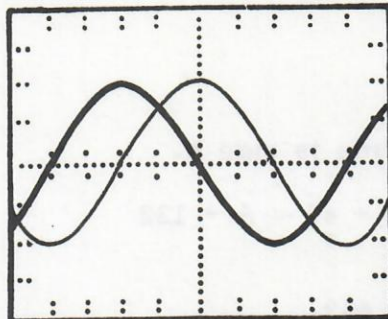


Figure 5 - Oscilloscope display for step 4.

6. Yes.

7. No.

9.

V_S	4	V
V_R	2.5	V
V_C	3.15	V

TABLE 1 - RC circuit voltages.

10. $\bullet (2.5) + (3.15) = 5.65 \text{ V}$

$\bullet$ The sum is 1.65 volts higher than the source, V_S .

12.

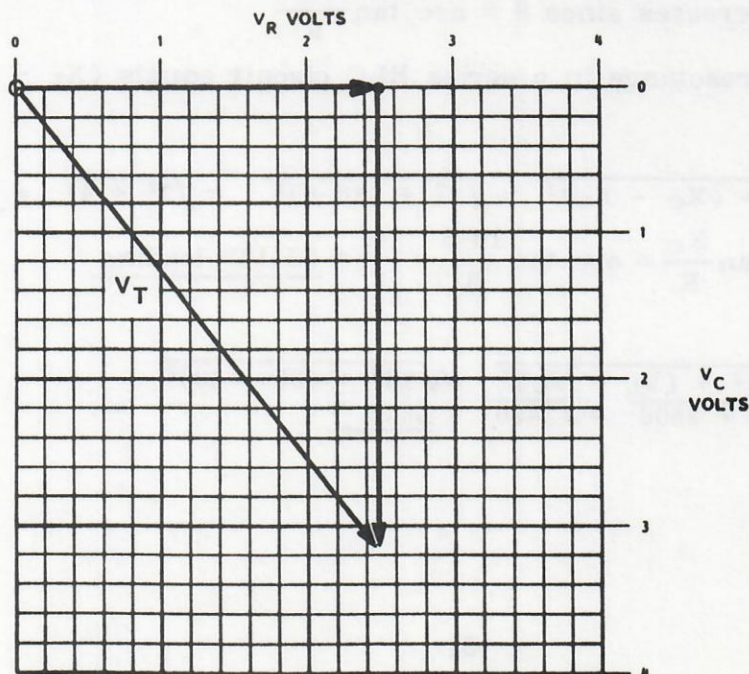


Figure 6 - Graph for construction of triangle solution.

$\bullet$ Hypotenuse length, 4 inches = 4 volts.

$\bullet$ They are equal.

ANSWERS G4 - EXPERIMENT NO. 3 (CONT)

EXPERIMENT NO. 3 - SERIES RC CIRCUITS (CONT)

13. ● $V_T = (2.5)^2 + (3.15)^2 = \sqrt{(16.17)} = \underline{4.02 \text{ V}}$
 ● Almost the same.
14. As f increases, X_C decreases reducing V_C . As X_C decreases, Z decreases to increase I . As I increases V_R increases.

$$15. I = \frac{(2.5)}{3.3 \text{ K}} = \underline{0.7575 \text{ mA}}$$

$$16. Z = \frac{4}{(0.7575)} = \underline{5,280 \text{ ohms}}$$

23.

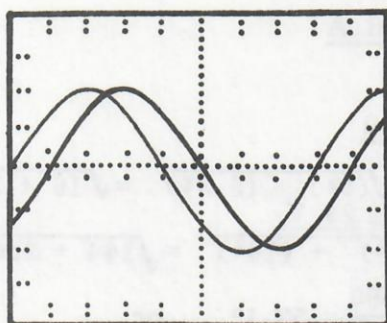


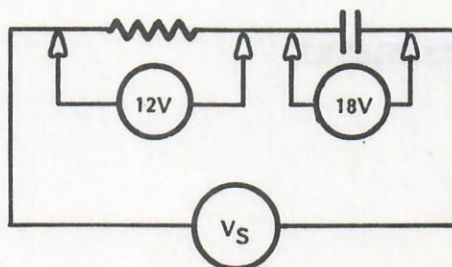
Figure 10 - Phase angle display EXPERIMENT.

● Measured $\theta = \underline{50^\circ}$

ASSIGNMENT

1. d All of the above.
2. b In a series RC circuit the leading component is recalled by ICE.
3. c Signal B appears 90° after signal A. Thus signal B lags signal A.
4. a The source voltage is 22.4 V.
 $V_S = \sqrt{R^2 + X_C^2} = \sqrt{(10^2) + (20^2)} = \sqrt{100 + 400} = \sqrt{500}$
 $V_S = \underline{22.36 \text{ V}}$
5. d None of the above. $Z = \sqrt{R^2 + X_C^2}$
6. a The phase angle in an RC circuit is equal to the difference, in degrees, between the circuit current and the voltage source.

7.

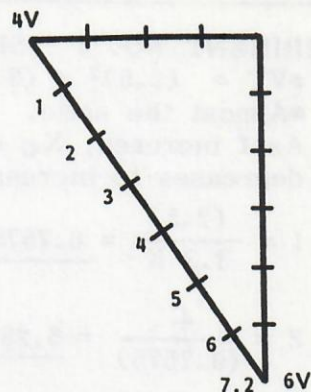
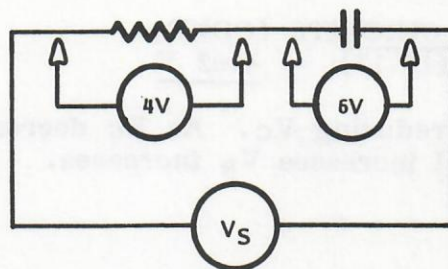


$$\begin{aligned} V_S &= \sqrt{E_R^2 + E_C^2} \\ &= \sqrt{12^2 + 18^2} \\ &= \sqrt{144 + 324} \\ V_S &= \underline{21.6 \text{ V}} \end{aligned}$$

ANSWERS G4 - EXPERIMENT NO. 3 (CONT)/EXPERIMENT NO. 4

EXPERIMENT NO. 3 - SERIES RC CIRCUITS (CONT)

8.



Proof $V_S = \sqrt{E_R^2 + E_C^2} = \sqrt{16 + 36}$
 $= \sqrt{52} = 7.21 \text{ V}$

9. Circuit $I = \frac{E}{R} = \frac{12}{4000} = 0.003 \text{ A}$

$X_C = \frac{E_C}{I_C} = \frac{16}{0.003} = 5,333 \Omega$

Circuit $Z = \sqrt{R^2 + X_C^2} = \sqrt{(42)^2 + (5.3^2)} = \sqrt{16 + 28.4} = 6.66 \text{ K}$
 10. $V_S = I_Z = 0.003 \times 6.66 \text{ K} \cong 20 \text{ V}$
 $V_S = \sqrt{E_R^2 + E_C^2} = \sqrt{(12^2) + (16^2)} = \sqrt{144 + 256} = \sqrt{400} = 20 \text{ V}$

11. $\theta = \arccos \frac{R}{Z} = \arccos \frac{4,000}{6,666} = 53.1^\circ$ or

$\theta = \arctan \frac{X_C}{R} = \arctan \frac{5,333}{4,000} = 53.1^\circ$ or

$\theta = \arcsin \frac{X_C}{Z} = \arcsin \frac{5,333}{6,666} = 53.1^\circ$

12. $\theta = \arccos \frac{R}{Z} = \arccos \frac{4}{20} = 78.5^\circ$

EXPERIMENT NO. 4 - SERIES RL CIRCUITS

PROCEDURE

5.

V_S	10	V_{p-p}	← PRESET
V_R	5	V_{p-p}	
V_L	9	V_{p-p}	

TABLE 1 - RL circuit voltages.

ANSWERS G4 - EXPERIMENT NO. 4 (CONT)

EXPERIMENT NO. 4 - SERIES RL CIRCUITS (CONT)

6. • $V_T = \sqrt{(5)^2 + (9)^2} = \sqrt{(25) + (81)} = \underline{10.3 \text{ V}}$
 • Very close. The small difference is due to error when reading the scope screen.

7. • $I_S = \frac{(5)}{3.3 \text{ K}} = \underline{0.0015 \text{ A}}$

• $Z = \frac{(10)}{(0.0015)} = \underline{6,666 \Omega}$

8. • $X_L = 5,181 \Omega$

• $Z = \sqrt{(3.3)^2 + (5.18)^2} = \underline{6,142 \Omega}$

• The error is less than 10% and is attributable to component tolerance, instrument calibration and errors in reading the data from the screen.

10.

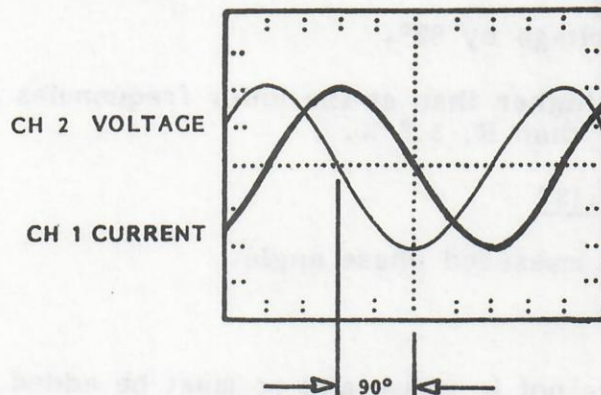


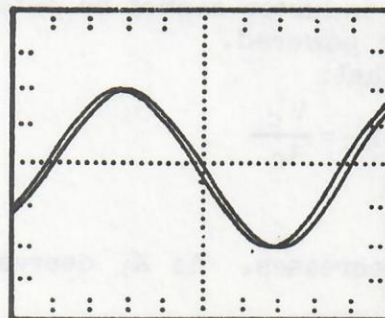
Figure 6 - Oscilloscope display of I_L on CH 1.

12. • It lags.
 • 90° .

14. $\theta = \arctan \frac{(5.18)}{3.3} = \underline{57.5^\circ}$

16. The phase angle measures 58.0° with the current lagging the voltage.

18.



• The current lags but by such a small angle that it cannot be measured on the oscilloscope.

ANSWERS G4 - EXPERIMENT NO. 4 (CONT)

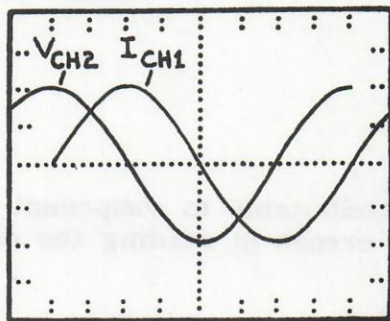
EXPERIMENT NO. 4 - SERIES RL CIRCUITS (CONT)

19. $\bullet X_L = 157 \Omega$

$\bullet \theta = \arctan \frac{(157)}{3,300} = 2.72^\circ$

$\bullet$ Both are much lower. θ is almost zero degrees and X_L is only 157 ohms.

20.



$\bullet$ The current lags the voltage by 85° .

21. $\bullet X_L = 15,700 \Omega$

$\bullet X_L$ at 100 kHz is much higher than at the lower frequencies and is almost 5 times greater than R , 3.3 K.

22.

$\bullet \theta = \arctan \frac{(15.7)K}{3.3 K} = 78.13^\circ$

$\bullet$ Within 7 degrees of the measured phase angle.

ASSIGNMENT

1. T

2. F The voltage drops are not in phase and so must be added using phasors or the Pythagorean Theorem.

3. T $V_S = \sqrt{V_R^2 + V_L^2} = \sqrt{21^2 + 28^2} = \sqrt{441 + 784}$
 $= \sqrt{1225} = 35 V$

4. T

$T = \frac{1}{f} = \frac{1}{20,000} = 50 \mu S$

5. T $\frac{360^\circ}{9} = 40^\circ \text{ per div.} \quad 3 \text{ div} = 3 \times 40 = 120^\circ$

6. F The impedance of an inductor cannot be determined using an ohmmeter which is dc powered.

7. F Ac ohms law states that:

$Z_L = \frac{V_L}{I_L} \quad \text{or} \quad Z_C = \frac{V_C}{I_C}$

8. T

9. T

10. F As f decreases X_L decreases. As X_L decreases θ decreases based on

$\theta \tan^{-1} = \frac{X_L}{R}$

ANSWERS G4 - EXPERIMENT NO. 4 (CONT)/EXPERIMENT NO. 5

EXPERIMENT NO. 4 - SERIES RL CIRCUIT (CONT)

CALCULATIONS

$$\begin{aligned}
 11. \quad a \quad I_S &= \frac{V_R}{R} = \frac{6}{3000} = \underline{0.002 \text{ A}} \\
 b \quad X_L &= 2\pi fL = 6.28 \times 10 \times 10^3 \times 50 \times 10^{-3} = \underline{3140 \Omega} \\
 c \quad V_L &= I_L \times X_L = 0.002 \times 3140 = \underline{6.28 \text{ V}} \\
 d \quad V_S &= \sqrt{V_R^2 + V_L^2} = \sqrt{6^2 + 6.28^2} = \underline{8.68 \text{ V}} \\
 e \quad Z &= \sqrt{R^2 + X_L^2} = \sqrt{3^2 + 3.14^2} = \underline{4.34 \text{ K}}
 \end{aligned}$$

EXPERIMENT NO. 5 - SERIES RLC CIRCUITS

PROCEDURE

4.

V_S	3	V	← PRESET
V_R	2.6	V	
V_L	1.3	V	
V_C	2.6	V	
V_{LC}	1.1	V	

TABLE 1 - RLC circuit voltages.

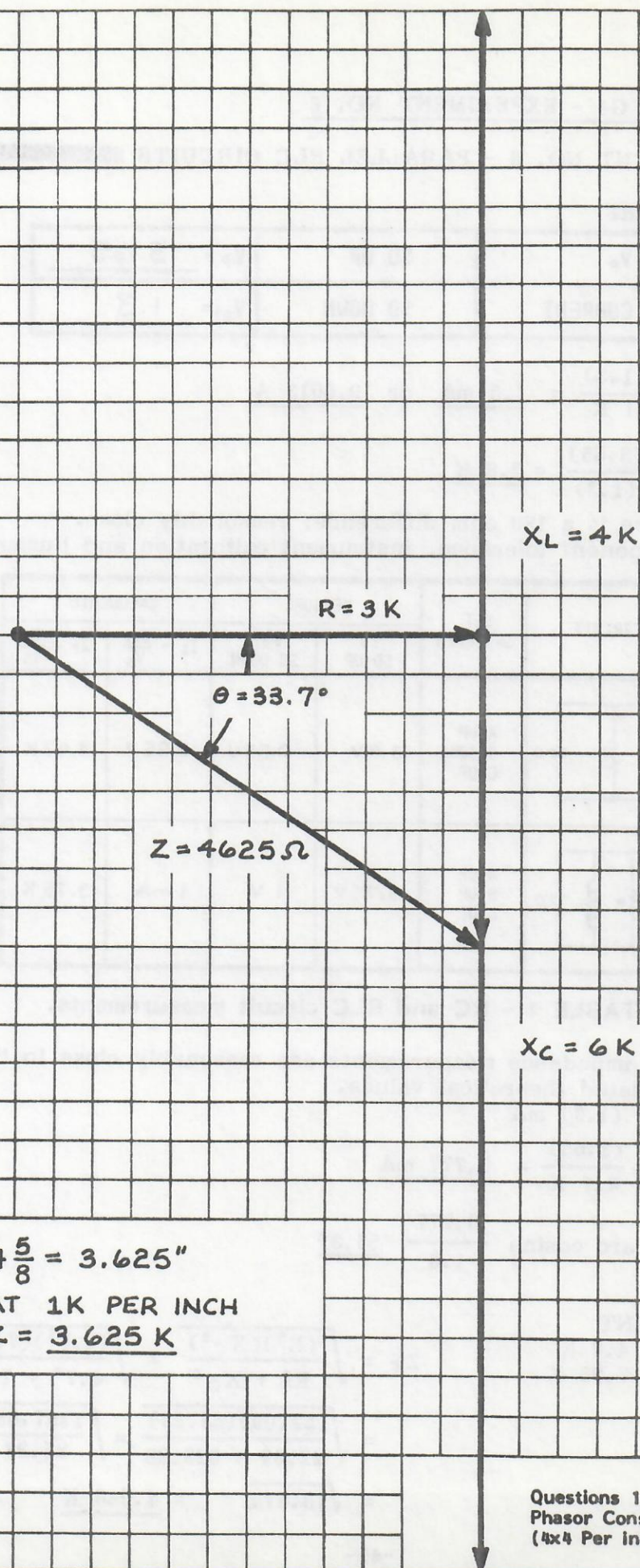
5. $\bullet V_A = (2.6) + (1.3) + (2.6) = \underline{6.5 \text{ V}}$
 $\bullet$ Voltage V_A is more than twice V_S . The voltages cannot be added directly because they are not in phase.
6. $\bullet V_X = (2.6) - (1.3) = \underline{1.3 \text{ V}}$
 $\bullet$ The voltage (1.1) reading is reasonably close to the expected value of 1.3 volts.
7. $V_T = \sqrt{(2.6)^2 + [(2.6) - (1.3)]^2} = \sqrt{(6.76) + (1.69)} = \underline{2.9 \text{ V}}$
8. $\bullet I_S = \frac{(2.6)}{2.2} \text{ mA} = \underline{1.182 \text{ mA}}$
 $\bullet Z = \frac{3}{(1.182) \text{ mA}} = \underline{2.538 \text{ K}}$
 $\bullet$ Very close.

ANSWERS G4 - EXPERIMENT NO. 5 (CONT)

EXPERIMENT NO. 5 - SERIES RLC CIRCUITS (CONT)

ASSIGNMENT

1. T
2. T
3. F X_C and X_L in series cancel because in X_C , I leads and in X_L , I lags thus producing a 180° phase difference.
4. T
$$X_C = \frac{1}{2\pi fC} = \frac{1}{(6.28)(10 \times 10^3)(0.05 \times 10^{-6})}$$
$$= \frac{10^3}{(6.28)(10)(0.05)} = \frac{1000}{3.14} = \underline{318.47 \Omega}$$
5. T $X_L = 2\pi fL = (6.28)(10 \times 10^3)(500 \times 10^{-3}) = \underline{31400 \Omega}$
6. T $Z = \frac{E}{I}$ where $I = \frac{V_R}{R} = \frac{4}{2200} = \underline{0.0018 A}$
$$Z = \frac{10}{0.0018} = \underline{5,555 \Omega}$$
7. F $V_{XL} = I_R \times X_L = (1.8 \times 10^{-3})(5 \times 10^3) = \underline{9 V}$
8. F $V_{XC} = I_R \times X_C = (1.8 \times 10^{-3})(10 \times 10^3) = \underline{18 V}$
9. T $V_{A-C} = (V_{XC} - V_{XL}) = (18 - 9) = \underline{9 V}$
10. F X_C will equal X_L at one frequency only.
11. See graph construction.
12. See graph construction.
13. $Z = \sqrt{(R^2) + (X_C - X_L)^2} = \sqrt{(3^2) + (6 - 4)^2}$
$$= \sqrt{9 + 4} = \underline{3.605 K}$$
14. $\theta = \arctan \frac{X_C}{R} = \frac{2 K}{3 K} = \underline{33.7^\circ}$



$$4 \frac{5}{8} = 3.625''$$

AT 1K PER INCH

$$Z = \underline{3.625 \text{ K}}$$

Questions 11, 12
Phasor Construction & Solution
(4x4 Per inch graph paper)

ANSWERS G4 - EXPERIMENT NO. 6

EXPERIMENT NO. 6 - PARALLEL RLC CIRCUITS

PROCEDURE

4.

V_p	SD UP	$V_p = \underline{3.65}$
CURRENT	SD DOWN	$V_{R1} = \underline{1.3}$

5. $I_s = \frac{(1.3)}{1 \text{ K}} = \underline{1.3 \text{ mA}}$ or $\underline{0.0013 \text{ A}}$

6. $Z = \frac{(3.65)}{(1.3)} = \underline{2.8 \text{ K}}$

• There is a 190 ohm difference; reasonably close.

• Component tolerance, instrument calibration and human error.

7.

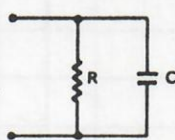
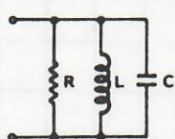
CIRCUIT	SET SWITCHES	MEASURE		CALCULATE	
		V_p SD UP	V_{R1} SD DOWN	$I_s = \frac{V_{R1}}{V_R}$	$Z_p = \frac{V_p}{I_s}$
	A UP B DOWN C UP	3.8 V	0.85 V	0.85 V	4.47 K
	A UP B UP C UP	3.75 V	1 V	1 mA	3.75 K

TABLE 1 - RC and RLC circuit measurements.

9. Both impedance measurements are reasonably close to the calculated theoretical values.

11. $I_s = (1.3) \text{ mA}$

• $I_R = \frac{(3.65)}{4.7 \text{ K}} = \underline{0.777 \text{ mA}}$

• $\theta = \arccosine \frac{0.777}{1.3} \underline{53.3^\circ}$

ASSIGNMENT

1. $R = 4.7 \text{ K}$
 $X_C = 7.96 \text{ K}$

$$\begin{aligned}
 Z_T &= \sqrt{\frac{(R^2)(X_C^2)}{R^2 + X_C^2}} = \sqrt{\frac{(4.7^2)(7.96^2)}{4.7^2 + 7.96^2}} \\
 &= \sqrt{\frac{(22.09)(63.28)}{22.09 + 63.28}} = \sqrt{\frac{1397.85}{85.37}} \\
 &= \sqrt{16.374} = \underline{4.046 \text{ K}}
 \end{aligned}$$

ANSWERS G4 - EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - PARALLEL RLC CIRCUITS (CONT)

2. $R = 4.7 \text{ K}$

$X_L = 3.4 \text{ K}$

$X_C = 7.96 \text{ K}$

$$I_R = \frac{V_P}{R} = \frac{10}{4.7} = \underline{2.128 \text{ mA}}$$

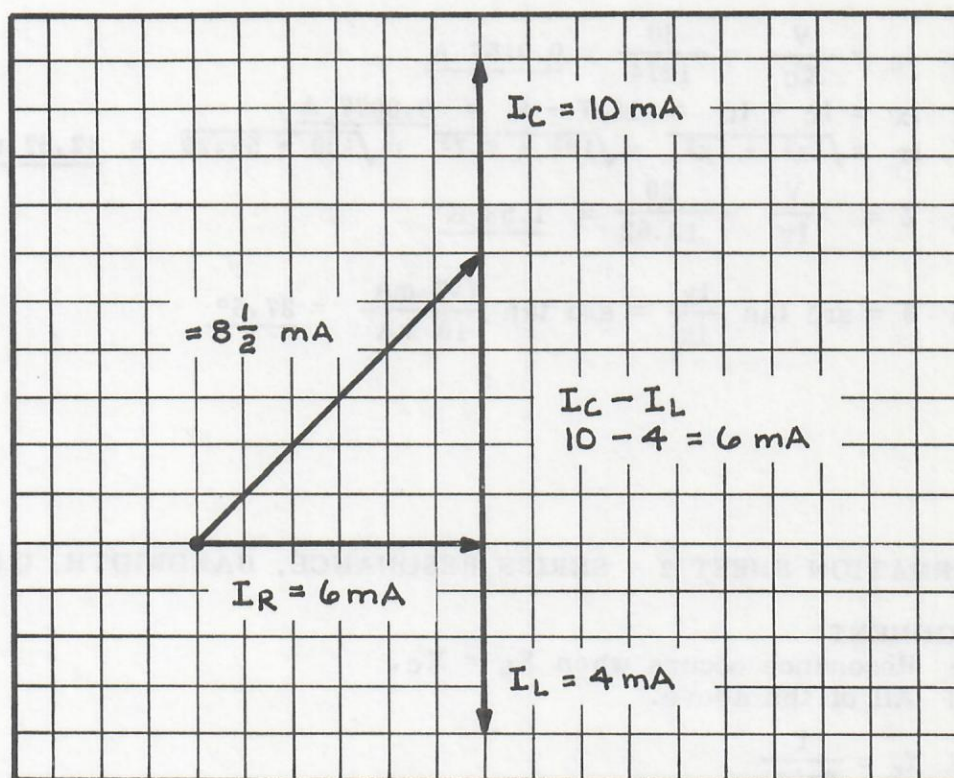
$$I_L = \frac{V_P}{X_L} = \frac{10}{3.4} = \underline{2.941 \text{ mA}}$$

$$I_C = \frac{V_P}{X_C} = \frac{10}{7.96} = \underline{1.256 \text{ mA}}$$

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2} = \sqrt{2.128^2 + (2.941 - 1.256)^2}$$

$$= \sqrt{4.528 + 2.839} = \sqrt{7.367} = Z_T = \underline{2.71 \text{ K}}$$

3.



$$4. \quad I_T = \sqrt{I_R^2 + (I_C - I_L)^2} = \sqrt{6^2 + (10-4)^2}$$

$$= \sqrt{6^2 + 6^2} = \sqrt{36 + 36} = \sqrt{72}$$

$$I_T = \underline{8.485 \text{ mA}}$$

5. Since this is a parallel RLC circuit, V_C equals V_S , the source voltage. Given that I_T in problem 4 is 8.485 mA:

$$Z_T = \frac{V_S}{I_T} = \frac{20}{8.485} = \underline{2.35 \text{ K}}$$

ANSWERS G4 - EXPERIMENT NO. 6 (CONT)/INFORMATION SHEET 2

EXPERIMENT NO. 6 - SERIES RLC CIRCUITS (CONT)

$$6. \quad a \quad X_C = \frac{1}{2\pi fC} = \frac{1}{(6.28)(2.5 \times 10^3)(0.05 \times 10^{-6})}$$

$$= \frac{10^3}{(6.28)(2.5)(0.05)} = \frac{10^3}{0.785} = \underline{1274 \, \Omega}$$

$$b \quad I_R = \frac{V}{R} = \frac{20}{2000} = \underline{0.01 \, A}$$

$$c \quad I_L = \frac{V}{X_L} = \frac{20}{2500} = \underline{0.008 \, A}$$

$$d \quad I_C = \frac{V}{X_C} = \frac{20}{1274} = \underline{0.0157 \, A}$$

$$e \quad I_X = I_C - I_L = 15.7 - 8 = \underline{0.0077 \, A}$$

$$f \quad I_T = \sqrt{I_R^2 + I_X^2} = \sqrt{10^2 + 7.7^2} = \sqrt{100 + 59.29} = \underline{12.62 \, mA}$$

$$g \quad Z = \frac{V}{I_T} = \frac{20}{12.62} = \underline{1.58 \, K}$$

$$h \quad \theta = \arctan \frac{I_X}{I_R} = \arctan \frac{7.7 \, mA}{10 \, mA} = \underline{37.6^\circ}$$

INFORMATION SHEET 2 - SERIES RESONANCE, BANDWIDTH, Q

ASSIGNMENT

1. c Resonance occurs when $X_L = X_C$.
2. d All of the above.

$$3. \quad c \quad f_r = \frac{1}{2\pi LC}$$

$$4. \quad a \quad 225.2 \, kHz$$

$$f_r = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{6.28 \sqrt{(100 \times 10^{-6})(0.005 \times 10^{-6})}}$$

$$= \frac{1}{6.28 \sqrt{0.5 \times 10^{-12}}} = \frac{1}{(6.28)(0.707)10^{-6}}$$

$$= \frac{10^6}{4.44} = \underline{225.2 \, kHz}$$

5. b The response curve of a resonant circuit is sharp if R is low.

ANSWERS G4 - INFORMATION SHEET 2 (CONT)/EXPERIMENT NO. 7

INFORMATION SHEET 2 - SERIES RESONANCE, BANDWIDTH, Q (CONT)

6. b $Q = 20$ $Q = \frac{X_L}{R}$ Since, at resonance, $X_L = X_C$, then

$$X_C = 1000 = X_L = 1000 \quad Q = \frac{1000}{50} = 20$$

7. c Skin effect is greatest when the operating frequency is highest.
8. c The bandwidth of a resonant circuit is measured between the half power points on the current curve.
9. d All of the above.
10. d All of the above.

EXPERIMENT NO. 7 - SERIES RESONANT CIRCUITS

PROCEDURE

3.

For $V_{in} = 3$ VOLTS	
f (kHz)	V_{out}
2	0.25
3	0.5
4	0.9
5	1.35
6	2.0
7	2.65
f_r 7.200 kHz	2.7
8	2.4
9	1.9
10	1.55
12	1.1
14	0.8

TABLE 1 - RLC band pass circuit output voltage.

5. $f_r = 7.2$ kHz $V_{out} = 2.7$ V

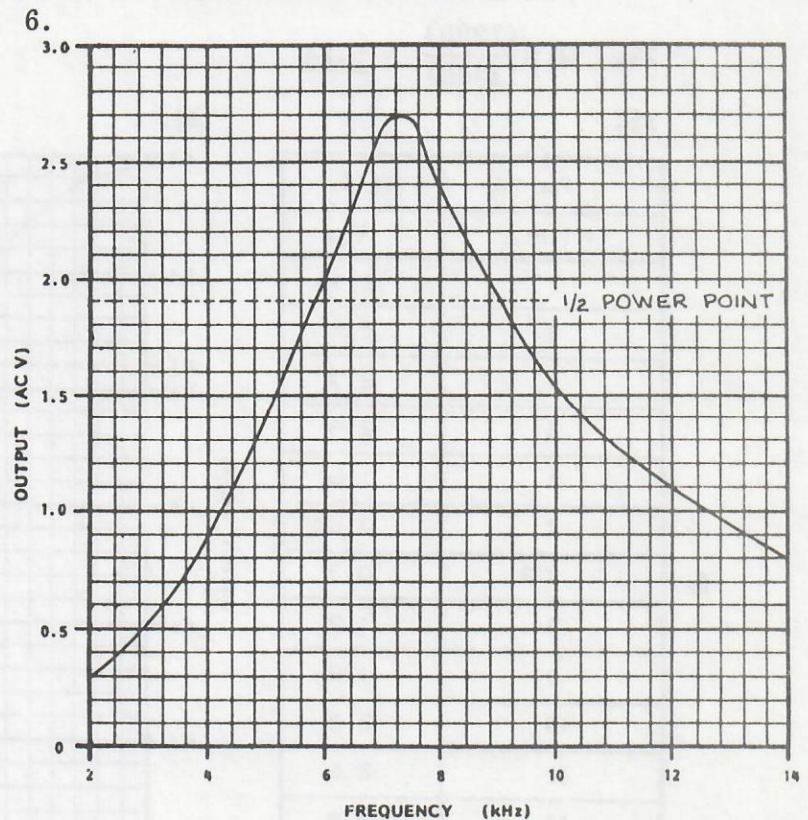


Figure 5 - Plot of V_{out} versus f for the series RLC circuit.

ANSWERS G4 - EXPERIMENT NO. 7 (CONT)

EXPERIMENT NO. 7 - SERIES RESONANT CIRCUITS (CONT)

7. $V_{\text{half power}} = (2.7)(0.707) = \underline{1.9 \text{ V}}$

9. $f_1 = \underline{5800 \text{ Hz}}$ $f_2 = \underline{9000 \text{ Hz}}$

10. $\text{BW} = (9000) - (5800) = \underline{3200 \text{ Hz}}$

12. $f_r = \underline{7200 \text{ Hz}}$

14. $f_2 = \underline{9300 \text{ Hz}}$ $f_1 = \underline{5600 \text{ Hz}}$

15. $\text{BW} = (9300) - (5600) = \underline{3700 \text{ Hz}}$

16. Very close, almost exact.

17. $Q = \frac{(7200)}{(3700)} = \underline{1.95}$

23. $f_r = \underline{7200 \text{ Hz}}$

24. $V_{\text{out}} = \underline{1.2 \text{ V}}$

25. $V_{\text{half power}} = (1.2)(0.707) = \underline{0.85 \text{ V}}$

26. $f_1 = \underline{6500 \text{ Hz}}$

27. $f_2 = \underline{7800 \text{ Hz}}$

28. $\bullet \text{BW} = (7800) - (6500) = \underline{1300 \text{ Hz}}$

$\bullet$ Yes. within 141 Hz.

$\bullet$ For $R = 1 \text{ K}$, the BW is 3.2 kHz. For $R = 200$, the BW is 1.3 kHz. The lower the resistance, the narrower the BW.

29. $Q = \frac{(7200)}{(1300)} = \underline{5.54}$

32.

For $V_{\text{in}} = 3 \text{ VOLTS}$	
$f \text{ (kHz)}$	V_{out}
2	2.95
3	2.9
4	2.7
5	2.4
6	1.6
7	0.25
7.2	0.2
8	1.2
9	1.9
10	2.3
12	2.6
14	2.8

f_r

34.

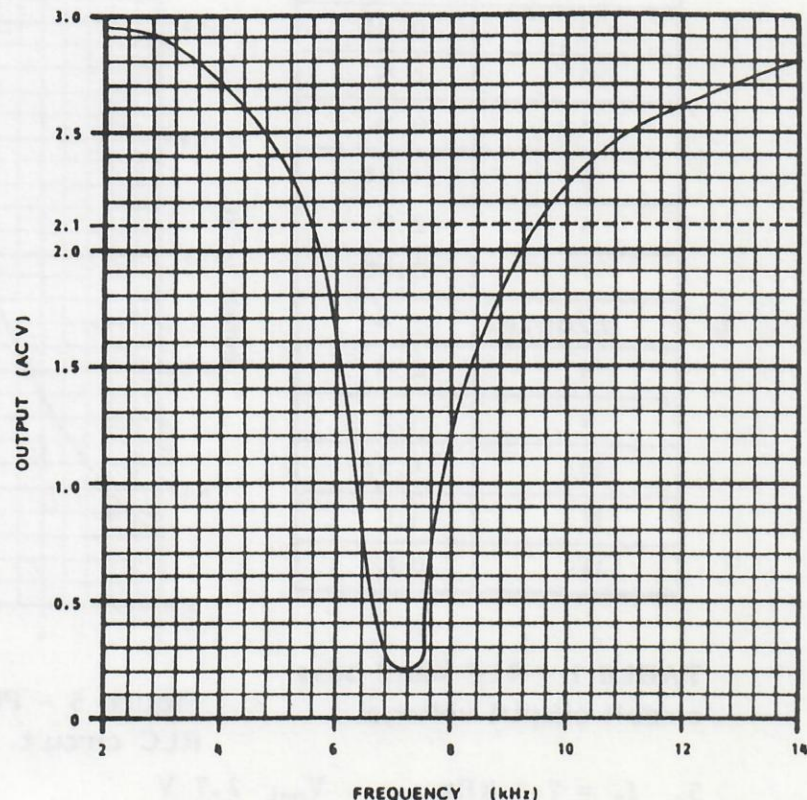


TABLE 2 - RLC Band stop circuit voltages.

Figure 9 - Graph to plot band stop response curve.

ANSWERS G4 - EXPERIMENT NO. 7 (CONT)

EXPERIMENT NO. 7 - SERIES RESONANT CIRCUITS (CONT)

35. $BW = (9500) - (5500) = \underline{4000 \text{ Hz}}$

36. $Q = \frac{(7200)}{(4000)} = \underline{1.8}$

ASSIGNMENT

1. d $X_C = X_L$

2. a R only.

3. c L and C in series.

4. d $f_r = \frac{1}{2\pi\sqrt{CL}}$ or $\frac{1}{2\pi\sqrt{LC}}$

5. a 56.27 kHz $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.28 \sqrt{(40 \times 10^{-3})(200 \times 10^{-12})}}$
 $= \frac{1}{6.28 \sqrt{8 \times 10^3 \times 10^{-15}}} = \frac{10^6}{6.28 (8)}$
 $= \frac{1,000,000}{17.77} = \underline{56,274 \text{ Hz}} = \underline{56.27 \text{ kHz}}$

6. d Any or all of the above.

7. d 0.5 mHz $BW = f_2 - f_1 = 2.6 - 2.1 = \underline{0.5 \text{ mHz}}$

8. b 318.47 Hz $BW = \frac{R}{2\pi L} = \frac{100}{(6.28)(0.05)} = \frac{100}{0.314} = \underline{318.47 \text{ Hz}}$

9. d 75.36 $Q = \frac{X_L}{R} = \frac{2\pi fL}{R} = \frac{(6.28)(100 \times 10^3)(0.03)}{250}$
 $= \frac{18840}{250} = \underline{75.36}$

10. a The power level at the half power points is half the power at resonance or

$$\frac{P_{fr}}{2} = \frac{0.006}{2} = \underline{0.003 \text{ W}}$$

11. a $f_r = 6.5 \text{ kHz}$ $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.28 \sqrt{(0.4 \times 10^{-3})(1.5 \times 10^{-6})}}$
 $= \frac{1}{6.28 \sqrt{6 \times 10^{-10}}} = \frac{10^5}{15.383} = \underline{6.5 \text{ kHz}}$

b $X_C = \frac{1}{2\pi fC} = \frac{1}{(6.28)(6.5 \times 10^3)(1.5 \times 10^{-6})}$
 $= \frac{1}{0.06123} = \underline{16.33 \Omega}$

c $X_L = 2\pi fL = (6.28)(6.5 \times 10^3)(0.4 \times 10^{-3}) = \underline{16.33 \Omega}$

ANSWERS G4 - EXPERIMENT NO. 7 (CONT)

EXPERIMENT NO. 7 - SERIES RESONANT CIRCUITS (CONT)

d $Z = R$ when $X_L = X_C$ (at resonance) = 3Ω

e $I_T = \frac{V_S}{Z} = \frac{3}{3} = \underline{1 \text{ A}}$

f $Q = \frac{X_L}{R} = \frac{16.33}{3} = \underline{5.44}$

g $BW = \frac{f_r}{Q} = \frac{6500}{5.44} = \underline{1195 \text{ Hz}}$

h $f_1 = (f_r) - \frac{BW}{2} = (6500) - \frac{1195}{2}$

$f_1 = (6500) - 597.5 = \underline{5902.5 \text{ Hz}}$

i $f_2 = (f_r) + \frac{BW}{2} = (6500) + \frac{1195}{2}$

$f_2 = (6500) + 597.5 = \underline{7097.5 \text{ Hz}}$

EXPERIMENT NO. 8 - SERIES RLC CIRCUIT VOLTAGES

PROCEDURE

4.

V_S	1 V
V_R	0.7 V
V_L	1.35 V
V_C	1.95 V

TABLE 1 - Voltage distribution in series RLC circuit.

5. Yes

6. Measured $V_{LC} = \underline{0.6 \text{ V}}$

7. $\bullet V_{LC} = (1.95) - (1.35) = \underline{0.6 \text{ V}}$

$\bullet$ Yes

8. $\bullet V_S = \sqrt{(0.7)^2 + [(1.95) - (1.35)]^2} = \sqrt{(0.49) + (0.36)} = \underline{0.92 \text{ V}}$

$\bullet$ Very close. The calculated voltage is off by only 0.08 volts

9. $\bullet V_{LC} = \underline{0.05 \text{ V}}$; $f_r = \underline{7.1 \text{ kHz}}$

$\bullet$ Almost exactly the same. A more accurate measurement is limited by the generator dial calibration.

ANSWERS G4 - EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - SERIES RLC CIRCUIT VOLTAGES (CONT)

10. ● V_R Down - X_L and X_C do not cancel. Z increases, thus I must decrease resulting in a lower V_R .
 ● V_L Down - Reduced current produces a smaller voltage drop across a lowered X_L .
 ● V_C Down - Reduced current lowers V_C below the resonant value but since X_C is up V_C has the highest of the three voltages.
 ● V_{LC} Up - Since V_L no longer equals V_C and they do not cancel out, this voltage reading will increase.

12.

V_S	1	V
V_R	0.5	V
V_L	0.7	V
V_C	1.6	V
V_{LC}	0.7	V

TABLE 2 - Voltage distribution at 5 kHz.

- Yes.
13. $V_R = 0.9 \text{ V}$; $f_r = 7.1 \text{ kHz}$
14. $V_S = 1 \text{ V}$; $V_L = 2.05 \text{ V}$
15. ● $Q = \frac{(2.05)}{1} = 2.05$
- Reasonably close. It is off because the coil resistance is ignored in the theoretical calculation.
18. Yes.
19. Yes.
21. $f_r = 6.9 \text{ kHz}$.
22. The circuit is capacitive because X_C and V_C are greater than X_L and V_L .
23. ● Less.
- As f increases, X_C decreases and X_L increases.
- The circuit is inductive because X_L is greater than X_C .
26. ● It lags V_S above resonance.
- Above resonance, the circuit is inductive. In an inductive circuit, I lags V_S .
27. ● It leads V_S below resonance.
- Below resonance, X_C exceeds X_L and the circuit is capacitive. In a capacitive circuit, I leads V_S .

ASSIGNMENT

- c In a series RLC circuit, at resonance, Z is equal to R .
- d All of the above.

ANSWERS G4 - EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - SERIES RLC CIRCUIT VOLTAGES (CONT)

3. c 150 kHz $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.28\sqrt{(4.5 \times 10^{-3})(250 \times 10^{-12})}}$
 $= \frac{10^6}{6.28\sqrt{1.125}} = \frac{10^6}{6.661} = \underline{150 \text{ kHz}}$
4. a 42,390 Ω $X_L = 2\pi fL = (6.28)(150 \times 10^3)(45 \times 10^{-3}) = \underline{42,390 \Omega}$
5. d 42,390 Ω At resonance X_C equals X_L .
6. b Impedance is minimum at f_r .
7. a The voltage drop across L is equal to $(I_S)(X_L)$ but since, at resonance, $X_L = X_C$, then V_L also equals $(I_S)(X_C)$.
8. c $I_S = \frac{V_S}{R}$ at resonance
9. a 19 $Q = \frac{V_L}{V_S} = \frac{58}{3} = \underline{19.33}$
10. a X_C increases because $X_C = \frac{1}{2\pi fC}$

V_C does not increase because I is lowered by the reduced X_L which no longer totally cancels X_C .

ANSWERS G5 - EXPERIMENT NO. 9

EXPERIMENT NO. 9 - PARALLEL RESONANCE

PROCEDURE

4. $f_r = 22,000 \text{ Hz}$

6. $f_1 = 17 \text{ kHz}; f_2 = 26 \text{ kHz}$

7. $BW = (26) - (17) = 9 \text{ kHz}$

8. $Q = \frac{(22)}{(9)} = 2.44$

•The circuit.

9. $Q = \frac{15,100}{(6.28)(22 \times 10^3)(50 \times 10^{-3})} = \frac{15,000}{(6908)} = 2.19$

•Very close.

10. $f_r = 22 \text{ kHz}$

11.

FREQUENCY IN kHz	VOLTAGE READINGS	
	PASS	STOP
1	0.025	3
5	0.3	2.95
10	0.7	2.9
15	1.4	2.6
20	2.8	1.8
25	2.4	1.15
30	1.55	2.1
35	1.1	2.4
40	0.84	2.55
45	0.7	2.7
50	0.55	2.75

TABLE 1 - Parallel resonant voltage readings.

12.

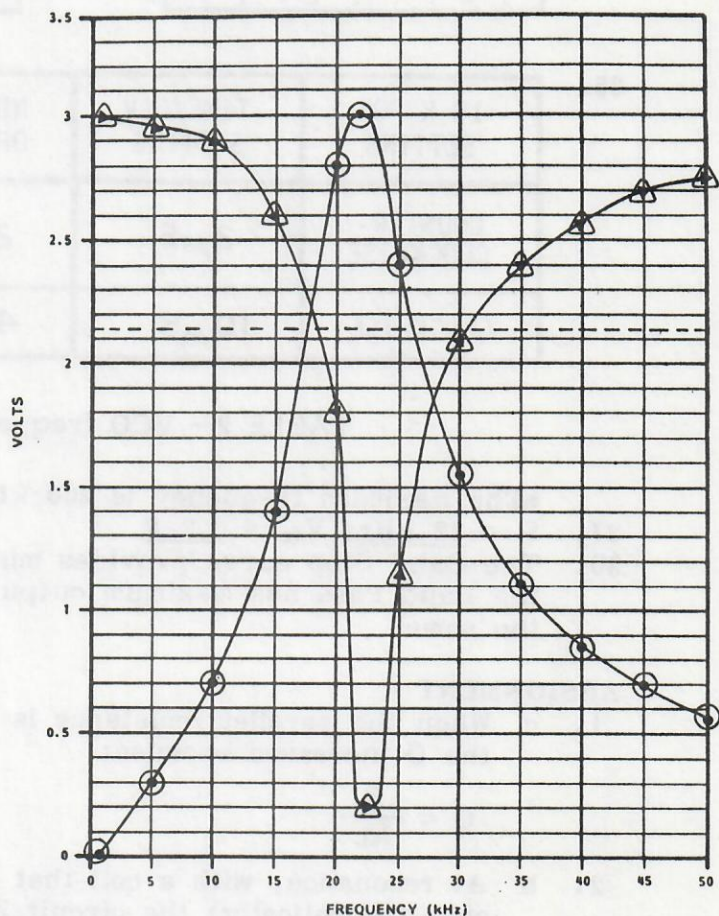


Figure 10 - Graph for plotting response curve.

14. The LC circuit picks up the signal at resonance even though there is no direct connection between the LC circuit and the source.

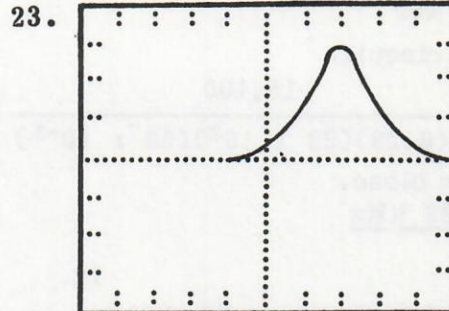
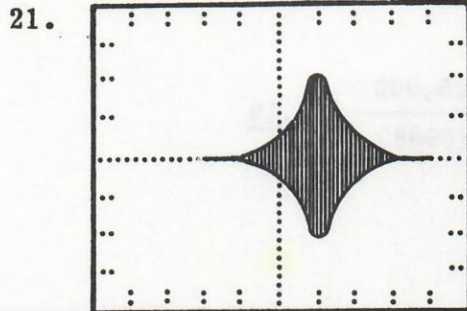
15. $f_r = \frac{1}{6.28 (10 \times 10^{-3})(0.001 \times 10^{-6})} = 50.35 \text{ kHz}$

ANSWERS G5 - EXPERIMENT NO. 9 (CONT)

EXPERIMENT NO. 9 - PARALLEL RESONANCE (CONT)

16. $f_r = 4.75 \text{ kHz}$

•The lower frequency is due to the capacity added to the LC circuit by the oscilloscope input circuit.



25.

10 K POT SETTING	TIME/DIV SETTING	NUMBER OF DIV	CALCULATED FREQUENCY
COUNTER-CLOCKWISE	$2 \mu\text{s}$	2.5	200,000 Hz
CLOCKWISE	$10 \mu\text{s}$	4.3	23,255 Hz

TABLE 2 - VCO frequency range.

•The maximum frequency is 200 kHz.

27. $f_r = 22 \text{ kHz}$; $V_{fr} = 0.2 \text{ V}$

30. The Band Stop curve provides minimum output at resonance while the Band Pass has maximum output at resonance. f_r for both is the same.

ASSIGNMENT

1. c When the parallel resistance is removed from the RLC circuit, the Q increases because:

$$Q = \frac{R}{X_L}$$

2. b At resonance, with a coil that has no resistance (possible only theoretically) the circuit Z is: $Z = R$
3. a In a parallel LC circuit, at resonance, the impedance is approximately equal to: $Z = (X_L)(Q)$
4. a In a parallel resonant circuit, Z is high and the current is low.

5. b $Q = \frac{I_{TANK}}{I_{LINE}}$

ANSWERS G5 - EXPERIMENT NO. 9 (CONT)/EXPERIMENT NO. 10

EXPERIMENT NO. 9 - PARALLEL RESONANCE (CONT)

6. d To increase the BW, lower the value of the parallel resistor because:

$$Q = \frac{R}{X_L} \quad \text{and} \quad BW = \frac{f_r}{Q}$$

7. d At resonance the circuit impedance is infinite and no current will be drawn after the tank circuit has been charged.

8. b In a parallel resonant circuit, I_L is 180° out of phase with I_C .

$$9. \quad b \quad Q = \frac{Z}{X_L} = \frac{Z}{2\pi fL} = \frac{60,000}{(6.28)(20 \times 10^3)(50 \times 10^{-3})} = \underline{9.55}$$

$$10. \quad d \quad f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.28\sqrt{(18 \times 10^{-3})(880 \times 10^{-12})}} = \frac{10^8}{2500} = \underline{40,000 \text{ Hz}}$$

$$BW = \frac{f_r}{Q} = \frac{40,000}{9.55} = \underline{800 \text{ Hz}}$$

EXPERIMENT NO. 10 - LC RADIO RECEIVER

PROCEDURE

4. $f_r = \underline{22 \text{ kHz}}$
 10. Depends upon number of local stations.
 11. Answers will vary with selection of station.
 13. Depends upon location.
 15. -Yes.
 -Depends upon area.

ASSIGNMENT

1. c Increase the value of the parallel capacitor.
 2. d The coil used has a low dc resistance and thus a higher Q.

$$3. \quad a \quad \underline{712 \text{ kHz}} \quad f_r = \frac{1}{6.28\sqrt{LC}} = \frac{1}{6.28\sqrt{(250 \times 10^{-6})(200 \times 10^{-12})}}$$

$$= \frac{1}{6.28\sqrt{50,000 \times 10^{-18}}} = \frac{10^9}{6.28\sqrt{50,000}} = \frac{1000}{1404} 10^6$$

$$f_r = \underline{0.712 \text{ MHz} = 712 \text{ kHz}}$$

4. a The parallel capacitance should be reduced.
 5. c Both a and b.

EXPERIMENT NO. 10 - RL FILTER CIRCUITS (CONT)

6. b 0.22 μ F

$$C = \frac{1}{4\pi^2 L f^2} = \frac{1}{(39.4)(16 \times 10^{-3})(2.68 \times 10^3)^2}$$

$$= \frac{1}{(3.94)(16 \times 10^{-3})(7.18 \times 10^6)} = \frac{10^{-3}}{(39.4)(16)(7.18)}$$

$$= \frac{10^{-3}}{4526.27} = \underline{0.22 \mu F}$$

7. b 100 kHz = 1×10^5 Hz. The period for one cycle is 10 μ S

$$f = \frac{1}{T} = \frac{1}{10 \times 10^{-6}} = \frac{10^6}{10} = \frac{1,000,000}{10} = \underline{100 \text{ kHz}}$$

8. c Amplify the audio signal.

EXPERIMENT NO. 11 - RL FILTER CIRCUITS

PROCEDURE

4. Yes. Output is flat at the low end and drops off as frequency is increased.

5.

f (Hz)	V _{OUT} (VOLTS)	f (kHz)	V _{OUT} (VOLTS)
100	3	6	2.3
200	3	7	2.2
300	3	8	2.0
400	3	9	1.9
500	3	10	1.8
600	3	20	1.0
700	3	30	0.7
800	3	40	0.5
900	3	50	0.4
1000	3	60	0.3
2000	2.95	70	0.2
3000	2.8	80	0.19
4000	2.7	90	0.1
5000	2.5	100	0.1

TABLE 1 - V_{OUT} versus frequency for the low pass filter.

ANSWERS G5 - EXPERIMENT NO. 11 (CONT)

EXPERIMENT NO. 11 - RL FILTERS CIRCUITS (CONT)

6.

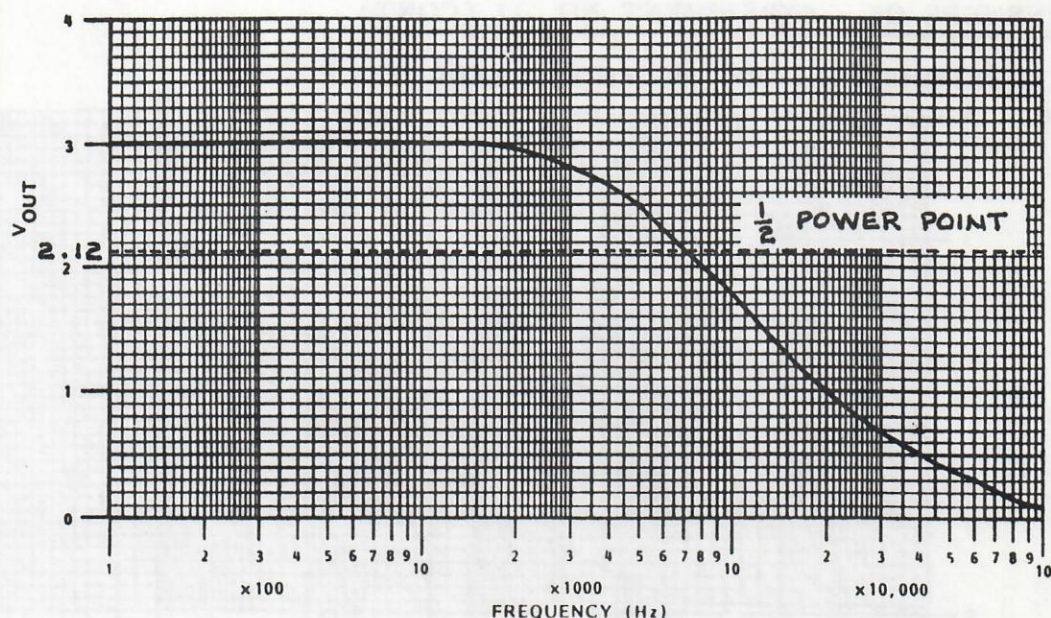


Figure 8 - Plot of output versus frequency for the RL low pass filter.

8. • $f_c = 7200 \text{ Hz}$
• Very close. Off by 194 Hz.
9. • $f_c = 7200 \text{ Hz}$.
• The measured f_c above agrees with the f_c read from the curve and is slightly higher (194 Hz) than the theoretical f_c .
12. $f_c = 7,900 \text{ Hz}$
- 13.

f (Hz)	V _{OUT} (VOLTS)	f (Hz)	V _{OUT} (VOLTS)
100	0.05	6000	1.8
200	0.1	7000	1.9
300	0.1	8000	2
400	0.1	9000	2.2
500	0.15	10000	2.3
600	0.17	20000	2.8
700	0.2	30000	3
800	0.25	40000	3
900	0.3	50000	3
1000	0.3	60000	3
2000	0.65	70000	3
3000	1.0	80000	3
4000	1.3	90000	3
5000	1.5	100000	3

TABLE 2 - V_{OUT} versus frequency for the high pass filter.

ANSWERS G5 - EXPERIMENT NO. 11 (CONT)

EXPERIMENT NO. 11 - RL FILTER CIRCUITS (CONT)

14.

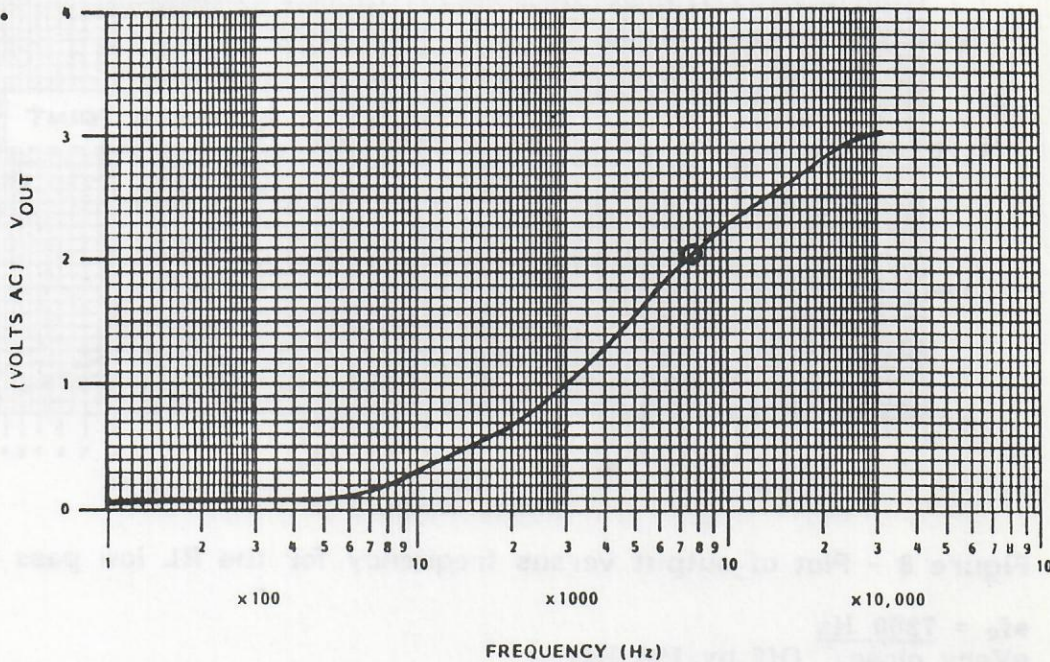


Figure 10 - Frequency response curve of the RL high pass filter.

ASSIGNMENT

1. b Block high frequencies and pass low frequencies.
2. d Pass high frequencies and block low frequencies.
3. a Low pass filter response curve.
4. d To the right of point C.
5. b The half power point is $0.707 \times 4 = 2.828$ volts, point C.
6. c $f_c = \frac{R}{2\pi L}$
7. c Semi log graph paper.
8. a 60 Hz, 250 Hz.
9. d High pass filter.
10. c $f_c = \frac{R}{2\pi L} = \frac{10 \times 10^3}{(6.28)(100 \times 10^{-3})}$
 $= \frac{1000}{628} \times 10^3 = 1.59 \times 10^3 = \underline{1,590 \text{ Hz}}$

ANSWERS G5 - EXPERIMENT NO. 12

EXPERIMENT NO. 12 - RC FILTER CIRCUITS

PROCEDURE

4. • $f_c = 4.225 \text{ Hz}$
 • Measured f_c is close to the theoretical value.
- 5.

f (Hz)	V_{OUT} (VOLTS)	f (kHz)	V_{OUT} (VOLTS)
200	3	4	2.2
300	3	5	1.9
400	3	6	1.7
500	3	7	1.5
600	3	8	1.3
700	3	9	1.2
800	3	10	1.1
900	3	20	0.6
1000	2.95	20	0.4
2000	2.7	40	0.3
3000	2.4	50	0.2

TABLE 1 - V_{OUT} versus frequency for the RC low pass filter.

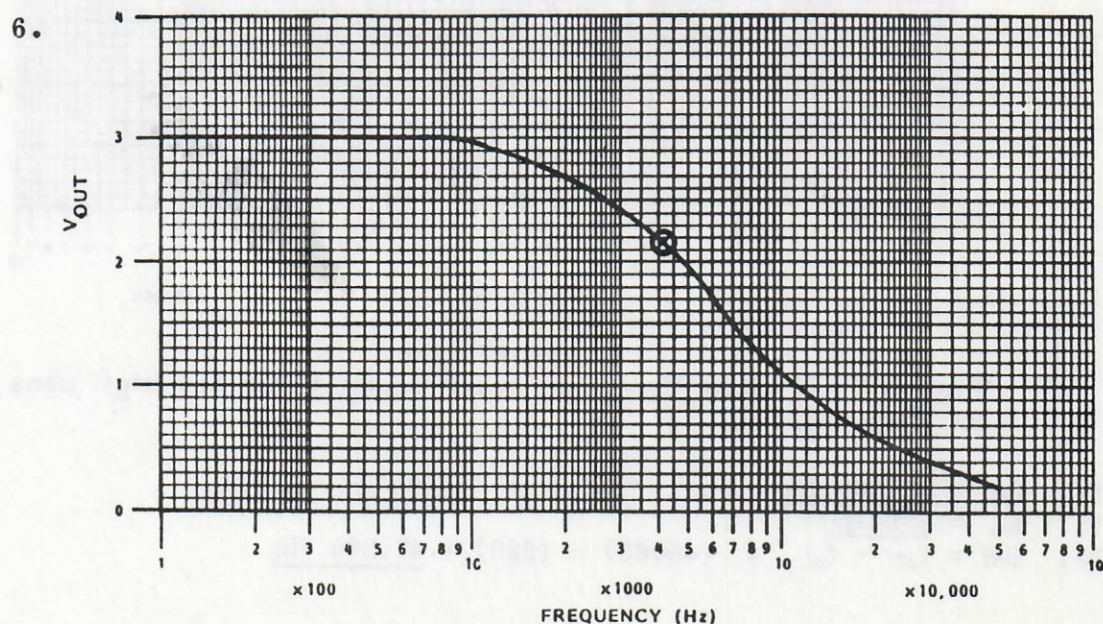


Figure 7 - Plot of V_{OUT} versus frequency for the low pass RC filter circuit.

9. $f_c = 4,600 \text{ Hz}$

ANSWERS G5 - EXPERIMENT NO. 12 (CONT)

EXPERIMENT NO. 12 - RC FILTER CIRCUITS (CONT)

10.

f (kHz)	V _{OUT} (VOLTS)	f (kHz)	V _{OUT} (VOLTS)
1	0.6	9	2.7
2	1.1	10	2.75
3	1.6	20	2.95
4	1.9	30	3
5	2.2	40	3
6	2.35	50	3
7	2.5	60	3
8	2.6	70	3

TABLE 2 - V_{OUT} versus frequency for the RC high pass filter.

11.

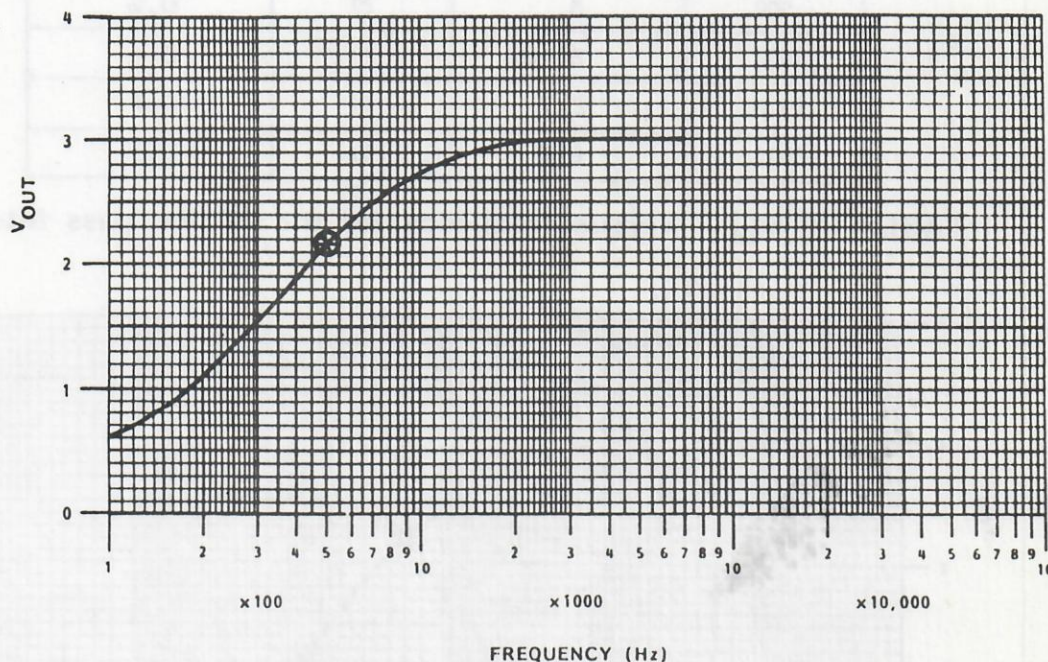


Figure 9 - Plot of V_{OUT} versus frequency for the high pass RC filter circuit.

14. $f_{c2} = \underline{48,000 \text{ Hz}}$

15. $f_{c1} = \underline{620 \text{ Hz}}$

16. $BW = f_{c2} - f_{c1} = (48000) - (620) = \underline{47,380 \text{ Hz}}$

ANSWERS G5 - EXPERIMENT NO. 12 (CONT)

17.

f (Hz)	V_{OUT} (VOLTS)	f (kHz)	V_{OUT} (VOLTS)
50	0.2	1	2.5
60	0.2	2	2.8
70	0.3	3	2.9
80	0.35	4	2.9
90	0.4	5	3.0
100	0.45	10	3.0
200	0.8	20	2.8
300	1.25	30	2.6
400	1.55	40	2.2
500	1.75	50	2.0
600	2.0	60	1.85
700	2.2	70	1.7
800	2.3	80	1.5
900	2.4	90	1.4

TABLE 3 - V_{OUT} versus frequency for the RC band pass filter.

18.

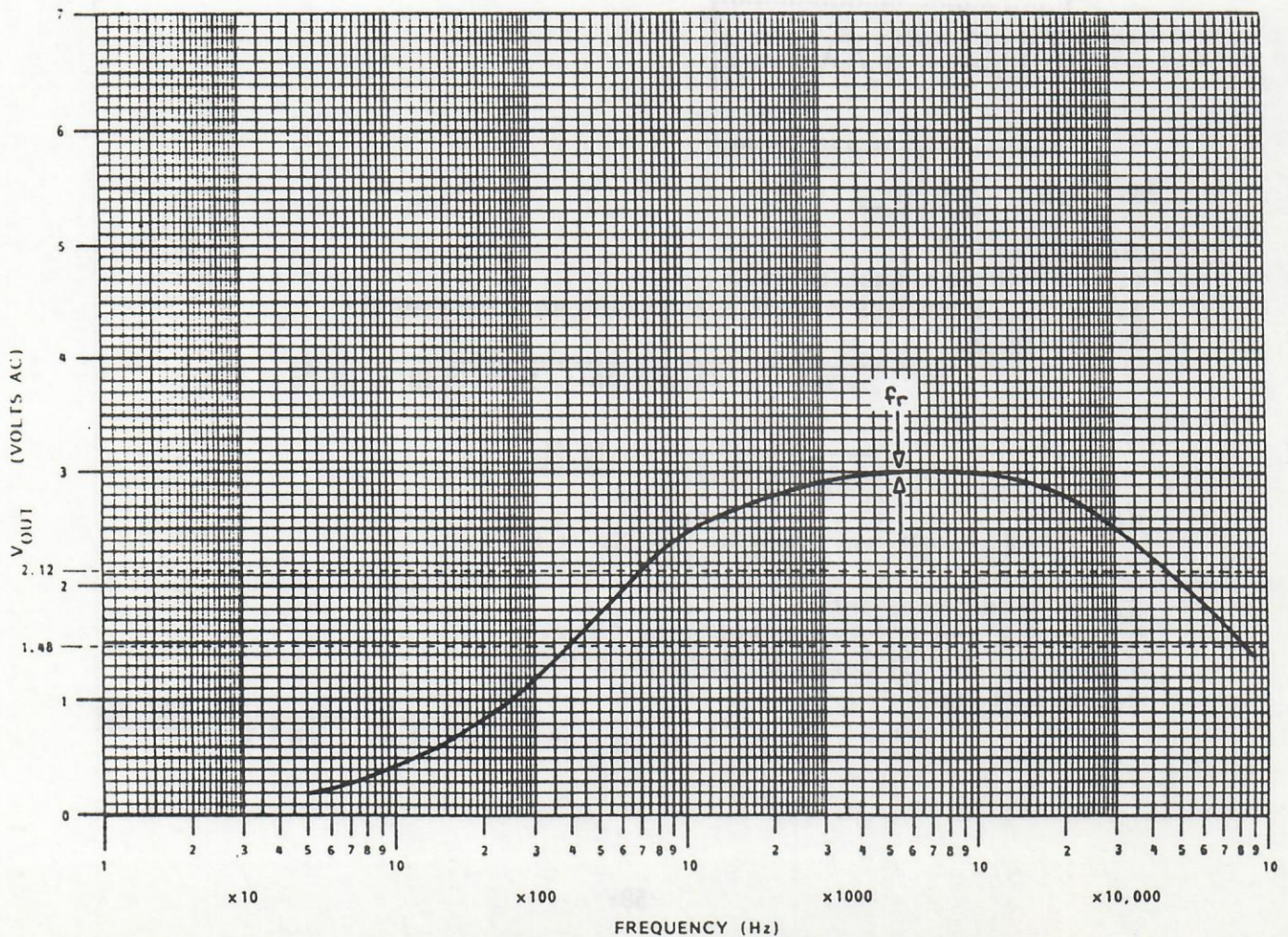
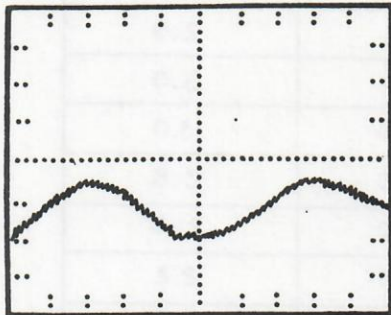


Figure 11 - Plot of V_{OUT} versus frequency for the RC band pass filter circuit.

ANSWERS G5 - EXPERIMENT NO. 12 (CONT)

EXPERIMENT NO. 12 - RC FILTER CIRCUITS (CONT)

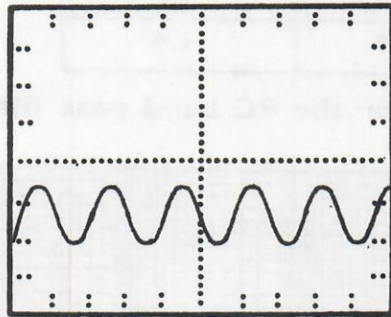
23.



24. • $V_{2K} = 1 V_{p-p}$; $V_{60} = 7.5 V_{p-p}$

• $ATTENUATION = \frac{V_{2K}}{V_{60 \text{ Hz}}} = \frac{(1)}{(7.5)} = \underline{0.133}$

25.



26. $V_{2K} = \underline{7.5 V_{p-p}}$

ASSIGNMENT

1. c RC high pass filter.
2. a X_C increases and V_o decreases as f decreases.
3. d 18 Hz

$$f_c = \frac{1}{2\pi RC} = \frac{1}{(6.28)(40 \times 10^3)(0.22 \times 10^{-6})}$$

$$= \frac{10^3}{(6.28)(4)(0.22)} = \underline{18 \text{ Hz}}$$

4. b $2X_C = 2R$ or $\frac{2X_C}{2} = \frac{2R}{2} = X_C = R$

5. d Band pass filter.
6. d R_2 and C_2 form a low pass filter.
7. c R_1 and C_1 form the high pass filter.

8. a 169 Hz

$$f_1 = \frac{1}{2\pi R_2 C_2} = \frac{1}{(6.28)(47 \times 10^3)(0.02 \times 10^{-6})} = \underline{169 \text{ Hz}}$$

ANSWERS G5 - EXPERIMENT NO. 12 (CONT)/EXPERIMENT NO. 13

EXPERIMENT NO. 12 - RC FILTER CIRCUITS (CONT)

9. c 16,940 Hz. $f_2 = \frac{1}{2\pi R_1 C_1} = \frac{1}{(6.28)(4.7 \times 10^3)(0.002 \times 10^{-6})} = \underline{16,940 \text{ Hz}}$

10. b 16,771 Hz. $BW = f_2 - f_1 = (16,940) - (169) = \underline{16,771 \text{ Hz}}$

EXPERIMENT NO. 13 - LC FILTER CIRCUITS

PROCEDURE

3. $V_o f_c = \underline{1.06 \text{ V}}$

4. $f_c = \underline{14 \text{ kHz}}$

5.

f (Hz)	V _{OUT} (VOLTS)	f (kHz)	V _{OUT} (VOLTS)
200	1.5	7	1.45
300	1.5	8	1.4
500	1.5	9	1.4
700	1.5	10	1.35
900	1.5	15	1.0
2000	1.5	20	0.7
3000	1.5	25	0.45
4000	1.5	30	0.3
5000	1.5	40	0.15
6000	1.5	50	0.1

TABLE 1 - V_{OUT} versus frequency for the low pass constant-k LC filter.

ANSWERS G5 - EXPERIMENT NO. 13 (CONT)

EXPERIMENT NO. 13 - LC FILTER CIRCUITS (CONT)

6.

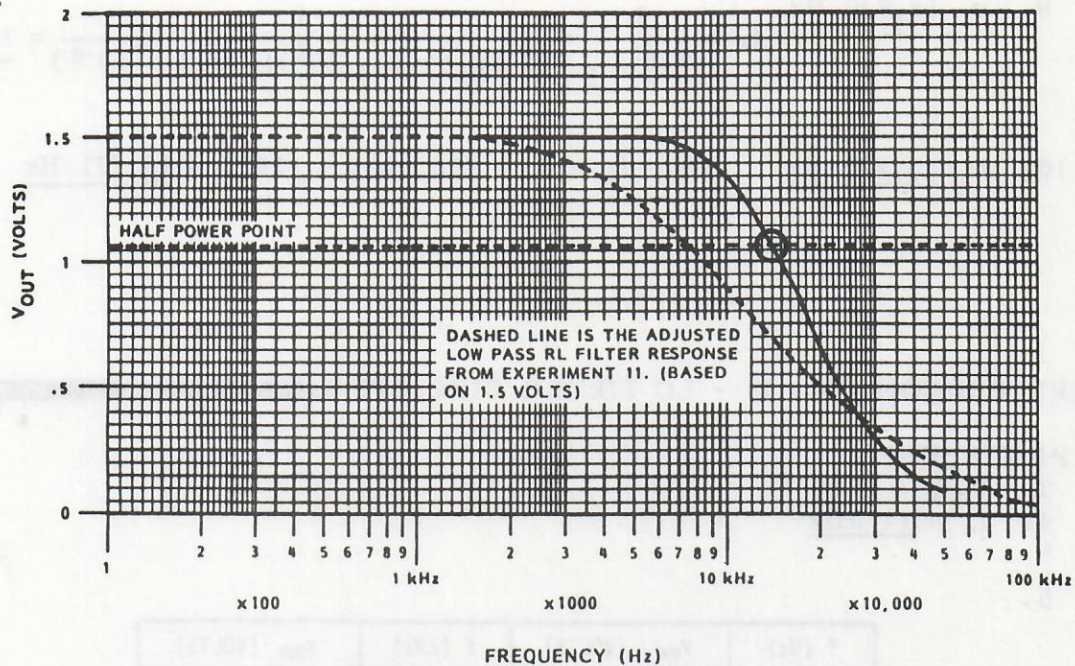


Figure 10 - Graph for plotting V_{OUT} versus frequency for the low pass LC filter; EXPERIMENT.

7. The roll-off of the LC filter is much sharper than that of the RC or RL filter.

10.

f (kHz)	V_{OUT} (VOLTS)	f (kHz)	V_{OUT} (VOLTS)
1	0.00	14	1.5
2	0.05	15	1.5
3	0.2	20	1.5
4	0.3	25	1.5
5	0.4	30	1.5
6	0.8	40	1.5
7	1.0	50	1.5
8	1.1	60	1.5
9	1.2	70	1.5
10	1.3	80	1.5
12	1.4	100	1.5

TABLE 2 - V_{OUT} versus frequency for the high pass constant-k LC filter.

ANSWERS G5 - EXPERIMENT NO. 13 (CONT)

EXPERIMENT NO. 13 - LC FILTER CIRCUITS (CONT)

11.

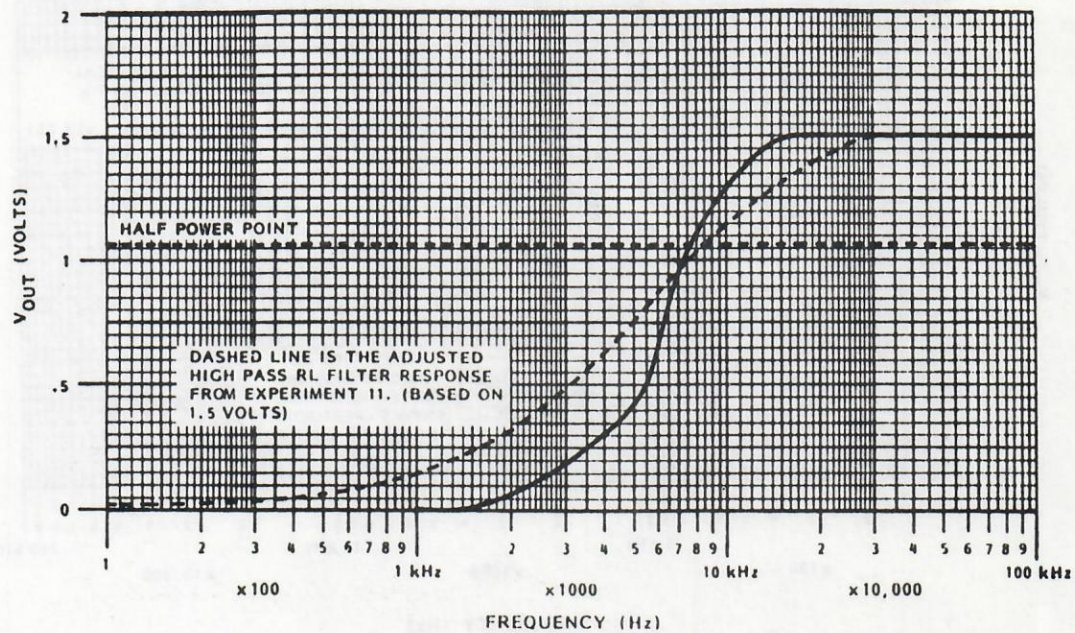


Figure 12 - Graph for plotting V_{OUT} versus frequency for the high pass constant-k LC filter; EXPERIMENT.

14.

f (Hz)	V_{OUT} (VOLTS)	f (kHz)	V_{OUT} (VOLTS)
100	3	1200	3.4
200	3.1	1400	2.4
300	3.15	1600	0.85
400	3.2	1800	0.4
500	3.3	2000	0.3
600	3.4	2200	0.2
700	3.5	2500	0.5
800	3.6	3000	0.7
900	3.65	3500	0.8
1000	3.7	4000	0.9

TABLE 3 - V_{OUT} versus frequency for the m-derived low pass filter shown in Figure 13.

15. $f_{\infty} = 2,200$ Hz; $V_o f_{\infty} = 0.15$ V
16. $V_{MAX} = 3.7$ V; $f_{MAX} = 1000$ Hz
17. $V_{fc} = 2.12$ V
18. $f_c = 1,400$ Hz

ANSWERS G5 - EXPERIMENT NO. 13 (CONT)

EXPERIMENT NO. 13 - LC FILTER CIRCUITS (CONT)

19.

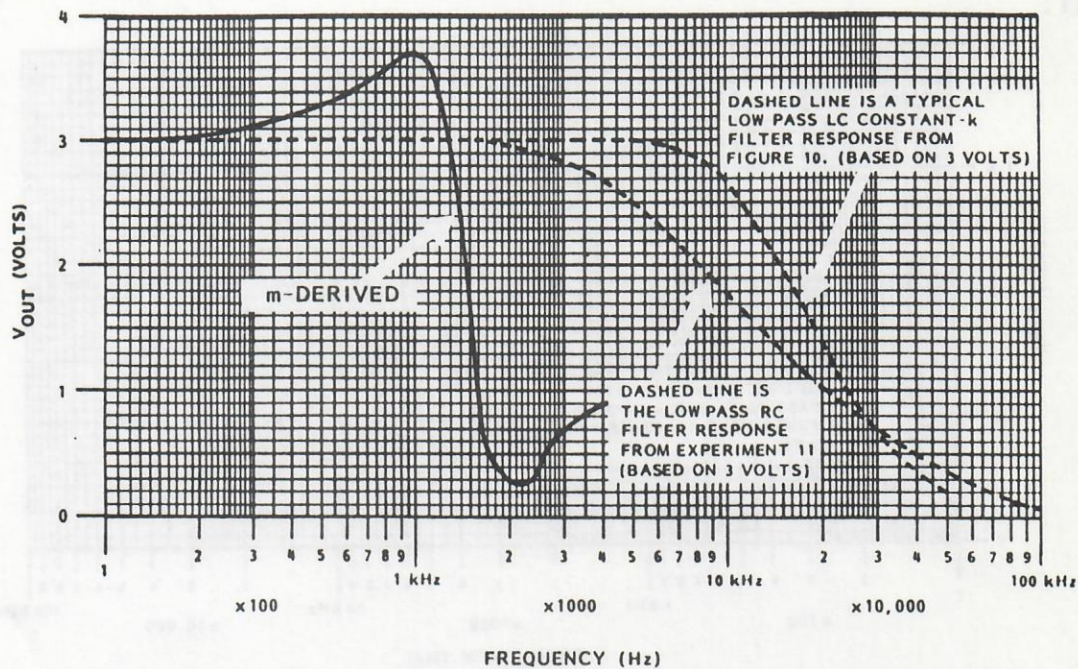


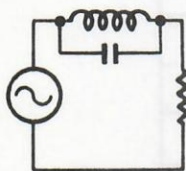
Figure 14 - Graph for plotting V_{OUT} versus frequency for the low pass m-derived filter; EXPERIMENT.

20. The RL Filter has the most gradual roll-off. The constant K filter is sharper than the RL and the m-derived filter has the sharpest roll-off of the three circuits.

$$21. \quad m = \sqrt{1 - \left(\frac{1.4}{2.2}\right)^2} = \sqrt{1 - (0.64)^2} = \sqrt{1 - (0.41)} = \sqrt{0.59} = \underline{0.768}$$

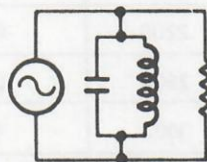
ASSIGNMENT

1. b



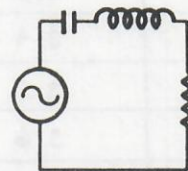
Bandstop

2. a



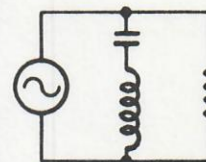
Bandpass

3. a



Bandpass

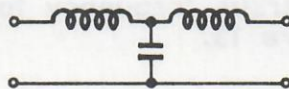
4. b



Bandstop

5. d all of the above.

6. a T configuration.



7. c L configuration.

8. b pi configuration.

9. d low pass constant-k filter.

10. c overshoot.

11. a f_c , the cut-off frequency.

ANSWERS G5 - EXPERIMENT NO. 13 (CONT)/EXPERIMENT NO. 14

EXPERIMENT NO. 13 - LC FILTER CIRCUITS (CONT)

12. d None of the above. Only an M-derived filter has an f_{∞} point.
The response shown is that of a constant-k filter.
13. b R_i should equal R_o .
14. a Low pass M-derived filter.
15. c Point C represents f_c , the cut-off frequency.
16. c Point A represents f_{∞} , called the infinite attenuation frequency.
17. d All of the above.
18. d None of the above. f_c occurs at $0.707 \times 3.1 \text{ V} = 2.192$ or 2.2 volts. The curve crosses 2.2 volts at 540 Hz.
19. b 250 Hz.
20. d All of the above.

EXPERIMENT NO. 14 - MUTUAL INDUCTANCE

PROCEDURE

3.

INDUCTOR	MEASURE		CALCULATE	
	V_R	V_L	$X_L = \frac{V_L}{V_R} (R)$	$L = \frac{X_L}{2\pi f}$
L1 = 10 mH	2.8	0.5	178.57 Ω	9.5 mH
L2 = 25 mH	2.5	1.2	480 Ω	25.5 mH
L3 = 50 mH	2.05	1.8	878 Ω	47 mH

TABLE 1 - Data for calculation of X_L and L.

5. $X_{L1} = \frac{(0.5)}{(2.8)} (K) \quad X_{L1} = \underline{0.17857 \text{ K}}$
6. $L = \frac{X_L}{2\pi f} = \frac{(178.57)}{(6.28)(3000)} = \frac{(178.57)}{(18840)} = \underline{0.00947 \text{ H or } 9.47 \text{ mH}}$
 - Very close, within 0.5 mH.
7. The 25 mH and 50 mH inductors both measure very close, well within the tolerance ratings.

ANSWERS G5 - EXPERIMENT NO. 14 (CONT)

EXPERIMENT NO. 14 - MUTUAL INDUCTANCE (CONT)

9.

INDUCTORS	MEASURE		CALCULATE	
	V_R	V_L	$X_L = \frac{V_L}{V_R}(R)$	$L = \frac{X_L}{2\pi f}$
SERIES AIDING L_{MAX}	2.1 V	1.65 V	785.7 Ω	41.7 mH
SERIES OPPOSING L_{MIN}	2.35 V	1.3 V	553.2 Ω	29.4 mH

TABLE 2 - Series aiding and opposing measurements.

11. When one inductor is reversed for series opposing, L_T drops from 41.7 mH to 29.4 mH.

$$12. M = \frac{L_{MAX} - L_{MIN}}{4} = \frac{(41.7) - (29.4)}{4} = \underline{3.075 \text{ mH}}$$

$$13. k = \frac{M}{\sqrt{L_1 L_2}} = \frac{(3.075)}{\sqrt{(10)(25)}} = \frac{(3.075)}{\sqrt{250}} = \underline{0.1945}$$

•Yes.

•Loose.

16.

INDUCTOR	MEASURE		CALCULATE	
	V_R	V_L	$X_L = \frac{V_L}{V_R}(R)$	$L = \frac{X_L}{2\pi f}$
DIRECTION 1	1.6	2.3	1437.5 Ω	76 mH
DIRECTION 2	1.6	2.3	1437.5 Ω	76 mH

TABLE 3 - Series 50 mH and 25 mH data.

18. •They are the same.

•Uncoupled inductors add directly; $25 + 50 = 75 \text{ mH}$.

$$19. L_T = L_1 + L_2 = (25) + (50) = \underline{75 \text{ mH}}$$

•Yes, off by 1 mH.

$$20. M = \frac{L_{MAX} - L_{MIN}}{4} = \frac{(76) - (76)}{4} = \underline{0 \text{ H}}$$

$$k = \frac{M}{L_1 - L_2} = \frac{(0)}{(50) - (25)} = \underline{0}$$

ANSWERS G5 - EXPERIMENT NO. 14 (CONT)

EXPERIMENT NO. 14 - MUTUAL INDUCTANCE (CONT)

22.

TRANSFORMER WINDINGS	MEASURE			CALCULATE	
	V_{IN}	V_R	V_L	$X_L = \frac{V_L}{V_R} (R)$	$L = \frac{X_L}{2\pi f}$
L_1 (1 to 2)	9	3.6	6	166.67 Ω	0.442 H
L_2 (2 to 3)	9	3.6	6	166.67 Ω	0.442 H
$L_1 + L_2$ (1 to 3)	10	1.5	9	600 Ω	1.59 H

TABLE 4 - Power transformer inductance measurements.

$$23. \bullet X_L = \frac{V_L}{V_R} = \frac{(6)(100)}{(3.6)} = \underline{166.67 \Omega}$$

$$\bullet L = \frac{X_L}{2\pi f} = \frac{(166.67)}{(6.28)(60)} = \underline{0.442 \text{ H}}$$

25. •Yes.

•The $L_1 - L_2$ winding is center-tapped and has an equal number of turns on each winding

$$28. \bullet X_L = \frac{V_L}{V_R} (R) = \frac{(9)}{(1.5)} (100) = \underline{600}$$

$$\bullet L_T = \frac{X_L}{2\pi f} = \frac{(600)}{(6.28)(60)} = \underline{1.6 \text{ H}}$$

•No. The inductance increases by the square of the number of turns. Doubling the turns increases L by 4 times.

$$29. M = \frac{L_T - L_1 - L_2}{2} = \frac{(1.6) - (0.422) - (0.422)}{2} = \underline{0.358 \text{ H}}$$

ASSIGNMENT

1. c $L_1 + L_2$ or 500 mH.

2. a Aiding; in parallel.

$$3. d \underline{15 \text{ H}} \quad L_T = L_1 + L_2 - 2M = 9 + 12 - 2(3) = \underline{15 \text{ H}}$$

$$4. d \underline{1.8 \text{ H}} \quad M = k \sqrt{L_1 L_2} = 0.6 \sqrt{2 \times 4.5} = 0.6 \sqrt{9} = 0.6 \times 3 = \underline{1.8 \text{ H}}$$

$$5. a \underline{1.05 \text{ H}} \quad M = \frac{L_{MAX} - L_{MIN}}{4} = \frac{10 - 5.8}{4} = \frac{4.2}{4} = \underline{1.05 \text{ H}}$$

$$6. b \underline{7 \text{ H}} \quad L_T = L_1 + L_2 + 2M \quad L_2 = L_T - L_1 + 2M = 12 - 3 + 2(1) = 12 - 5 = \underline{7 \text{ H}}$$

ANSWERS G5 - EXPERIMENT NO. 14 (CONT)/EXPERIMENT NO. 15

EXPERIMENT NO. 14 - MUTUAL INDUCTANCE (CONT)

7. c 0.55

$$k = \frac{M}{\sqrt{L_1 L_2}} = \frac{25}{\sqrt{(20.25)(100)}} = \frac{25}{\sqrt{2025}} = \frac{25}{45} = \underline{0.55}$$

EXPERIMENT NO. 15 - POWER FACTOR MEASUREMENTS

PROCEDURE

3.

V_S	4	V	← PRESET
V_R	2.05	V	
V_L	3.2	V	

TABLE 1 - Voltage distribution in Figure 5.

4. $I_S = \frac{V_R}{R} = \frac{(2.05)}{1000} = \underline{0.0025 \text{ A or } 2.05 \text{ mA}}$

5. $P_{APP} = V_S I_S = (4)(2.05) = \underline{8.2 \text{ mVA}}$

6. $P_{TRUE} = V_R I_S = (2.05)(2.05) = \underline{4.2 \text{ mW}}$

7. $PF = \frac{P_{TRUE}}{P_{APP}} = \frac{(4.2)}{(8.2)} = \underline{0.51}$

8. $\bullet X_L = \underline{1570} \quad Z = \sqrt{1000^2 + 1570^2} = \underline{1861.4 \Omega}$

$\bullet PF = \frac{R}{Z} = \frac{1000}{(1861.4)} = \underline{0.537}$

9. $\theta = \arccos \frac{R}{Z} = \arccos \frac{(1000)}{(1861.4)} = \underline{57.5^\circ}$

10. $PF = \cos \theta = \cos (57.5^\circ) = \underline{0.537}$

12.

V_{R1}	3.8	V	(Left 1 K Resistor)
V_P	17.5	V	
V_{RL}	4.15	V	(Right 1 K Resistor)

TABLE 2 - Voltage distribution in Figure 7 with SA open.

ANSWERS G5 - EXPERIMENT NO. 15 (CONT)

EXPERIMENT NO. 15 - POWER FACTOR MEASUREMENTS (CONT)

13. $P_{APP} = (17.5)(3.8) = \underline{66.5 \text{ mW}}$

14. $P_{TRUE} = \frac{V_{RL}^2}{R_L} = \frac{(4.15)^2}{1000} = \underline{17.22 \text{ mW}}$

15. $\bullet PF = \frac{P_{TRUE}}{P_{APP}} = \frac{(17.22)}{(66.5)} = \underline{0.259}$

$\bullet P_{LOST} = \underline{49.3 \text{ mW}}$

16.

V_{R1}	2.4	V
V_P	18	V
V_{RL}	4.2	V

TABLE 3 - Voltage distribution in Figure 7 with SA closed.

17. $\bullet P_{TRUE} = \frac{V_{RL}^2}{R_L} = \frac{(4.2)^2}{1000} = \underline{17.64 \text{ mW}}$

$\bullet P_{APP} = V_P I_P = (18)(2.4) = \underline{43.2 \text{ mW}}$

$\bullet P_{TRUE}$ is almost the same, 0.22 mW higher.

$\bullet$ The apparent power for which we pay has dropped from 66.5 mVA to 43.2 mVA.

18. $\bullet PF = \frac{P_{TRUE}}{P_{APP}} = \frac{(17.64)}{(43.2)} = \underline{0.408}$

$\bullet$ Yes.

ASSIGNMENT

1. c Power in an ac circuit is the same as the power in a dc circuit when the load is resistive.

2. d All of the above.

3. c In an ac resistive-reactive load, the power that has to be paid for is the apparent power.

4. a $\underline{376.8 \Omega}$ $X_L = 2\pi fL = (6.28)(60)(1) = \underline{376.8 \Omega}$

5. b $\underline{390 \Omega}$ $Z = \sqrt{R^2 + X_L^2} = \sqrt{100^2 + 377^2} = \underline{390 \Omega}$

6. a $\underline{0.308 \text{ A}}$ $I = \frac{E}{Z} = \frac{120}{390} = \underline{0.308 \text{ A}}$

7. c $\underline{37 \text{ VA}}$ $P_{APP} = E_{rms} \times I_{rms} = (120)(0.308) = \underline{37 \text{ VA}}$

8. b $\underline{9 \text{ W}}$ $P_{TRUE} = I^2 R = (0.308)^2 (100) = \underline{9.49 \text{ W}}$

9. d $\underline{0.26}$ $PF = \frac{R}{Z} = \frac{100}{390} = \underline{0.256}$

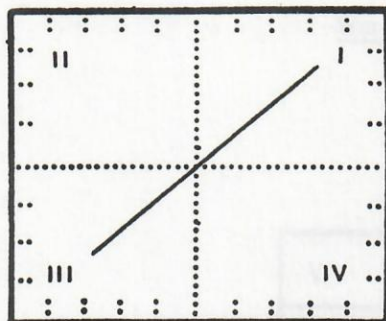
$$PF = \frac{P_{TRUE}}{P_{APP}} = \frac{9.49}{37} = \underline{0.256}$$

10. c Adding a correct value capacitor across the motor in Figure 9, will result in decreasing the apparent power dissipation.

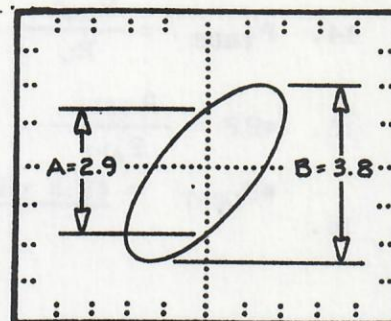
EXPERIMENT NO. 16 - LISSAJOUS PATTERNS

PROCEDURE

4.



7.



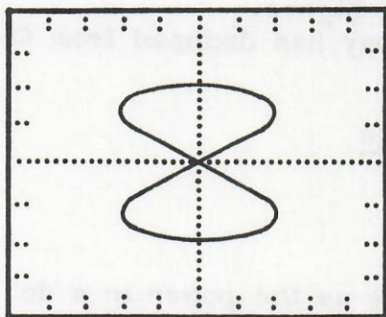
8. $A = \underline{2.9 \text{ DIVISIONS}}$
 $B = \underline{3.8 \text{ DIVISIONS}}$

9. $\theta = \arcsin \frac{A}{B} = \arcsin \frac{(2.9)}{(3.8)} = \arcsin (0.7636) \quad \theta = \underline{49.78^\circ}$

10. $\bullet \theta = \arctan \frac{X_C}{R} = \arctan \frac{39,809}{33,000} = \arctan (1.206) \quad \theta = \underline{50.3^\circ}$

•Very close, less than 0.5° difference.

13.

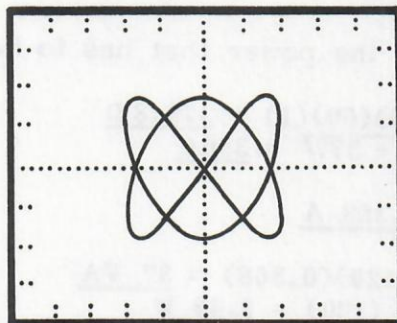


14.

$$\frac{f_v}{60} = \frac{(1)}{(2)}$$

$$f_v = \underline{30 \text{ Hz}}$$

15.



$$\frac{f_v}{60} = \frac{(3)}{(2)}$$

$$(2)f_v = (3)(60)$$

$$f_v = \underline{90 \text{ Hz}}$$

ANSWERS G5 - EXPERIMENT NO. 16 (CONT)

EXPERIMENT NO. 16 - LISSAJOUS PATTERNS (CONT)

16.

TEST FREQUENCY (Hz)	GENERATOR DIAL SETTING (Hz)	PATTERN RATIO
30	31	1:2
60	60	1:1
90	89.5	3:2
120	120	2:1
180	180	3:1
240	239	4:1
300	300	5:1
360	359	6:1
420	420	7:1
480	475	8:1

TABLE 1 - Generator dial readings versus 60 Hz.

17.

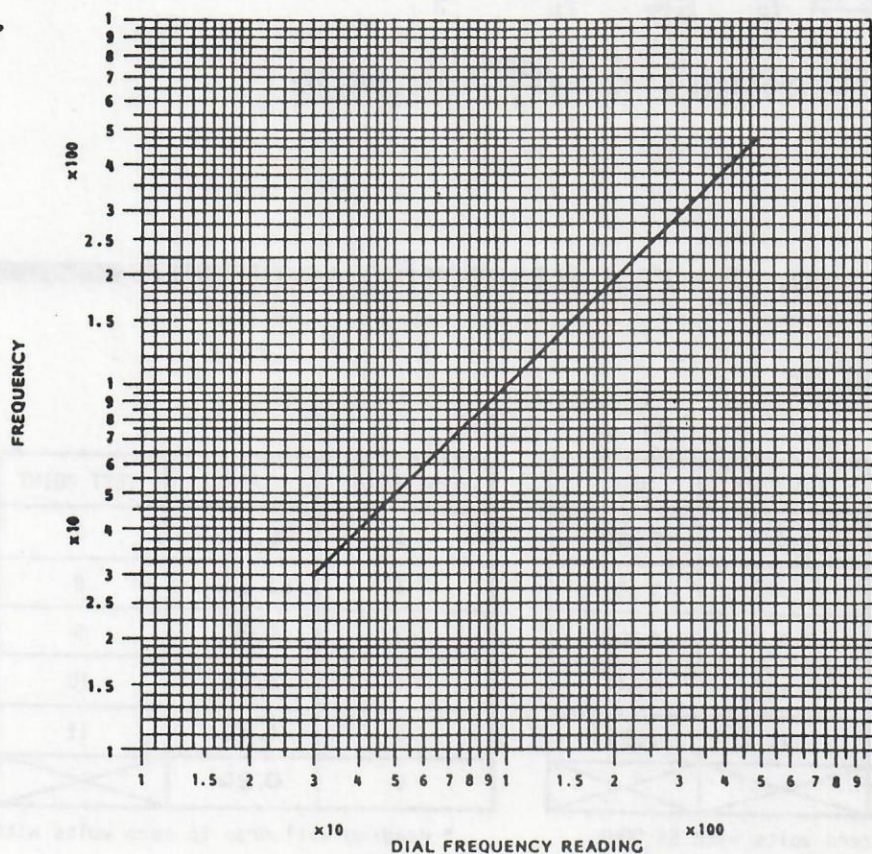


Figure 15 - Plot of Function Generator dial readings versus actual frequency.

•Correct plus or minus 1 or 2 Hz.

ANSWERS G5 - EXPERIMENT NO. 16 (CONT)/EXPERIMENT NO. 17

EXPERIMENT NO. 16 - LISSAJOUS PATTERNS (CONT)

ASSIGNMENT

1. b 8 kHz. $T = \frac{(5 \text{ cm})(50 \mu\text{S})}{2 \text{ cycles}} = \frac{250}{2} = 125 \mu\text{S}$

$$f = \frac{1}{T} = \frac{1}{125} = \underline{8,000 \text{ Hz}}$$

2. a dual trace oscilloscope; Lissajous Pattern.

3. b 25.37° $\theta = \arcsin \frac{Y_I}{Y_M} = \arcsin \frac{1.5}{3.5} \quad \theta = \underline{25.377^\circ}$

4. c A Lissajous display of a perfect circle indicates both a 90° phase difference and a 1:1 frequency ratio.

5. d 333.33 Hz $\frac{f_V}{f_H} = \frac{V_{TP}}{H_{TP}} = \frac{f_V}{200} = \frac{5}{3} = f_V(3) = (200)(5)$

$$f_V = \frac{1000}{3} = \underline{333.33 \text{ Hz}}$$

6. c 1,200 Hz $\frac{f_V}{f_H} = \frac{V_{TP}}{H_{TP}} = \frac{2000}{f_H} = \frac{5}{3}$

$$f_H(5) = (2000)(3) \quad f_H = \frac{6000}{5} = \underline{1,200 \text{ Hz}}$$

EXPERIMENT NO. 17 - TROUBLESHOOTING AC CIRCUITS

PROCEDURE

4. $f_\infty = \underline{1700 \text{ Hz}}$

5.

TEST POINT	DCV	TEST POINT	DCV
1	0.866	7	0.00
2	0.00	8	1.31
3	9.00	9	-0.43
4	1.33	10	* 0.15
5	1.33	11	1.31
6	0.00		

* Reading will drop to zero volts with SA DOWN.

TABLE 2 - Normal dc voltages for the circuit of Figure 2.

6.

TEST POINT	ACV	TEST POINT	ACV
1	4.36	7	0.184
2	10.26	8	0.822
3	0.00	9	0.822
4	3.23	10	* 0.286
5	1.82	11	0.822
6	0.26		

* Reading will drop to zero volts with SA DOWN.

TABLE 3 - Normal ac voltages for the circuit of Figure 2.

ANSWERS G5 - EXPERIMENT NO. 17 (CONT)

EXPERIMENT NO. 17 - TROUBLESHOOTING AC CIRCUITS (CONT)

7.

TEST POINT	WAVEFORM		P-P VOLTAGE LEVEL
	NORMAL	ABNORMAL	
1	✓		12 V
2	✓		30 V
3			0 V
4	✓		15 V
5	✓		8 V
6	✓		0.8 V
7	✓		0.7 V
8	✓		2.5 V
9	✓		2.5 V
10	✓		0.7 V
11	✓		2.5 V

TABLE 4 - Normal waveform check and p-p voltages.

13. Answers will vary with faults selected by the instructor.

ASSIGNMENT

- d For no 1500 Hz output, the most logical test sequence is 7; 6; 5; 4; 1.
- a For no 60 Hz output, the most logical test sequence is 10; 9; 8; 5; 4; 2.
- b The fault is in the Detector Stage.
- d The normal waveform at TP 4 should be 60 Hz riding on the 1500 Hz component.
- b A +1.3 volts at TP 9 is caused by a shorted C4 capacitor.
- c If the 1500 Hz signal level is very low at TP 8, the circuit is behaving normally.
- d Any of the above.
- b Placing SA in the DOWN position will cause the dc level at TP 10 to drop to zero.

ANSWERS OF - EXPERIMENT NO. IV (CONT)

EXPERIMENT NO. IV - TROUBLESHOOTING AC CIRCUITS (CONT)

TEST VOLTAGE	WAVEFORM		P-P VOLTAGE (VOLT)
	MEASURE	APPROXIMATE	
1	✓		1.5 V
2	✓		20 V
3	X		5 V
4			15 V
5	✓		5 V
6	✓		0.5 V
7	✓		0.7 V
8	✓		0.8 V
9	✓		1.2 V
10	✓		0.7 V
11	✓		2.5 V

TABLE 1 - Normal operation check and p-p voltages

12. Answers will vary with faults selected by the instructor.

ASSIGNMENT

- For no 1500 Hz output, the most logical test sequence is 1; 6; 7; 4; 1.
- For no 60 Hz output, the most logical test sequence is 10; 9; 8; 3; 4; 1.
- The fault is in the Detector Stage.
- The output waveform at TP 4 should be 60 Hz riding on the 1500 Hz component.
- A 1-2 volt at TP 2 is caused by a shorted C2 capacitor.
- If the 1500 Hz signal level is very low at TP 2, the circuit is behaving normally.
- Any of the above.
- Placing B+ in the DOWN position will cause the dc level at TP 10 to drop to zero.

Unit Test

G1 – AC Voltages and Components

Link Test

61-AC Voltages and Components

Unit Test

Part G1—AC Voltages and Components

Answer the following multiple choice questions.

1. A dc power distribution system to homes and factories:
 - a. cannot cover a large geographical area because of power line voltage drops.
 - b. is no longer in use.
 - c. does not allow the voltage to be stepped up.
 - d. all of the above.
2. In an ac power distribution system that covers a large geographical area, the voltage:
 - a. is stepped down for long runs.
 - b. is stepped up for long runs.
 - c. losses are great because the current is low.
 - d. none of the above.
3. It is possible to transmit radio waves between two points when a (an):
 - a. high dc voltage is applied to the antenna.
 - b. low dc voltage is applied to the antenna.
 - c. ac voltage is connected to the antenna.
 - d. any of the above.
4. An earphone:
 - a. is a magnetically operated device.
 - b. is used to convert an electrical signal to equivalent sound.
 - c. may also be used as a microphone.
 - d. all of the above.
5. An ac voltage can be generated by a (an):
 - a. electronic oscillator circuit.
 - b. rotary magnetic generator.
 - c. both a and b.
 - d. neither a nor b.
6. The measurements for an ac wave are:
 - a. frequency and period.
 - b. wavelength and pitch.
 - c. peak and peak-to-peak voltage.
 - d. all of the above.

Self Test

Part 21--AC Voltage and Components

Answer the following multiple-choice questions.

1. A AC power distribution system is known as a power line system.

- a. correct power a large geographical area because of power line voltage drops.
- b. is no longer in use.
- c. does not allow the voltage to be stepped up.
- d. all of the above.

2. In an AC power distribution system that covers a large geographical area, the voltage:

- a. is stepped down for long runs.
- b. is stepped up for long runs.
- c. remains the same because the current is low.
- d. none of the above.

3. It is possible to transmit radio waves between two points when a (an):

- a. high AC voltage is applied to the antenna.
- b. low AC voltage is applied to the antenna.
- c. AC voltage is connected to the antenna.
- d. any of the above.

4. An antenna:

- a. is a magnetically operated device.
- b. is used to convert an electrical signal to mechanical energy.
- c. may also be used as a microphone.
- d. all of the above.

5. An AC voltage can be generated by a (an):

- a. electronic oscillator circuit.
- b. rotary magnetic generator.
- c. both a and b.
- d. neither a nor b.

6. The measurements for an AC wave are:

- a. frequency and period.
- b. wavelength and phase.
- c. peak and peak-to-peak voltage.
- d. all of the above.

7. When the frequency of an ac voltage applied to a lamp is:
- a. 20 Hz, the lamp will light but flicker.
 - b. 40 Hz, the lamp will light but flicker.
 - c. 50 Hz, the lamp will not light.
 - d. none of the above.
8. A dc voltmeter may be used to measure ac voltages:
- a. just as it is, without any changes.
 - b. when a diode is placed in series with the meter.
 - c. if the correct multiplying factor is used.
 - d. when a capacitor is wired in series with the meter.
9. The standard range of sound frequencies is considered to be:
- a. 20 Hz to 20 kHz.
 - b. 20 Hz to 200 kHz.
 - c. 100 Hz to 10,000 Hz.
 - d. none of the above.
10. Two successive alternations of an ac sine wave:
- a. cover 360° .
 - b. are alternately positive and negative.
 - c. each have the same peak voltage.
 - d. all of the above.
11. The instantaneous voltage of a sine wave at 90° , given that the peak voltage is 100V, is:
- a. 70.7 volts.
 - b. 100 volts.
 - c. 170.7 volts.
 - d. 200 volts.
12. A sine wave that has a period of 20 mS has a frequency of:
- a. 20 Hz.
 - b. 40 Hz.
 - c. 50 Hz.
 - d. 60 Hz.
13. An ac signal of 400 Hz has a period of:
- a. 400 mS.
 - b. 25 mS.
 - c. 2.5 mS.
 - d. 4 mS.
14. A 100 volt rms sine wave has a peak voltage of _____ and a peak-to-peak voltage of _____.
- a. 100 volts; 200 volts.
 - b. 141 volts; 282 volts.
 - c. 200 volts; 400 volts.
 - d. 50 volts; 200 volts.

1. When the frequency of an ac voltage applied to a lamp is:
 - a. 20 Hz, the lamp will light but flicker.
 - b. 40 Hz, the lamp will light but flicker.
 - c. 60 Hz, the lamp will not light.
 - d. none of the above.
2. A dc voltmeter may be used to measure ac voltages:
 - a. just as it is, without any changes.
 - b. when a diode is placed in series with the meter.
 - c. if the correct multiplying factor is used.
 - d. when a capacitor is placed in series with the meter.
3. The standard range of sound frequencies is considered to be:
 - a. 20 Hz to 20 kHz.
 - b. 20 Hz to 200 kHz.
 - c. 100 Hz to 10,000 Hz.
 - d. none of the above.
4. Two successive alternations of an ac sine wave:
 - a. cover 360°.
 - b. are alternately positive and negative.
 - c. each have the same peak voltage.
 - d. all of the above.
5. The instantaneous voltage of a sine wave at 90°, given that the peak voltage is 100V, is:
 - a. 70.7 volts.
 - b. 100 volts.
 - c. 141.4 volts.
 - d. 200 volts.
6. A sine wave that has a period of 20 ms has a frequency of:
 - a. 20 Hz.
 - b. 50 Hz.
 - c. 50 Hz.
 - d. 10 Hz.
7. An ac signal of 400 Hz has a period of:
 - a. 400 ms.
 - b. 25 ms.
 - c. 2.5 ms.
 - d. 1 ms.
8. A 100 volt rms sine wave has a peak voltage of _____ and a peak-to-peak voltage of _____.
 - a. 100 volts; 200 volts.
 - b. 141 volts; 282 volts.
 - c. 100 volts; 400 volts.
 - d. 50 volts; 200 volts.

15. A sine wave that has an rms value of 120 volts has a (an):
- peak value of 170 volts.
 - peak-to-peak value of 340 volts.
 - average value of 76 volts.
 - all of the above.
16. A capacitor may be defined as a component that has two:
- insulators separated by a conductor.
 - conductors separated by a thin film of copper.
 - conductors separated by a non-conductor.
 - any of the above.
17. A capacitor, when charging, has a:
- high current, initially, which then drops gradually.
 - low current, initially, which then rises until the capacitor is fully charged.
 - rising current, which peaks at the end of 1 TC.
 - answers a and c but not b.
18. In a capacitor that is charging, as one electron:
- enters the positive plate, one electron leaves the negative plate.
 - enters the negative plate, one electron leaves the positive plate.
 - leaves the positive terminal of the voltage source one electron leaves the positive terminal of the charging capacitor.
 - none of the above.
19. As the area of the plates of a capacitor are made larger, the capacity:
- increases by the square of the plate area.
 - increases.
 - decreases.
 - decreases by the square of the plate area.
20. As the distance separating the capacitor plates is increased, the capacity will:
- decrease.
 - decrease by the square of the plate area.
 - increase.
 - increase by the square of the distance.

12. A sine wave that has an rms value of 120 volts has a peak value of:

- a. peak value of 170 volts.
- b. peak-to-peak value of 340 volts.
- c. average value of 75 volts.
- d. all of the above.

13. A capacitor may be defined as a component that has two:

- a. insulation separated by a conductor.
- b. conductors separated by a thin film of copper.
- c. conductors separated by a non-conductor.
- d. any of the above.

14. A capacitor, when charging, has a:

- a. high current, initially, which then drops gradually.
- b. low current, initially, which then rises until the capacitor is fully charged.
- c. rising current, which peaks at the end of 1 T.C.
- d. constant current and a constant voltage.

15. In a capacitor that is charging, an electron:

- a. enters the positive plate, and electron leaves the negative plate.
- b. enters the negative plate, and electron leaves the positive plate.
- c. leaves the positive terminal of the voltage source and electron leaves the positive terminal of the charging capacitor.
- d. none of the above.

16. As the area of the plates of a capacitor are made larger, the capacity:

- a. increases by the square of the plate area.
- b. increases.
- c. decreases.
- d. decreases by the square of the plate area.

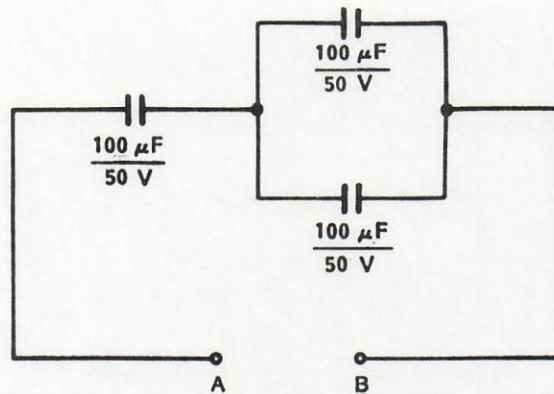
17. As the distance separating the capacitor plates is increased, the capacity will:

- a. decrease.
- b. decrease by the square of the plate area.
- c. increase.
- d. increase by the square of the distance.

21. The higher the constant of a dielectric used in a capacitor, the:
- higher the breakdown voltage rating.
 - lower the capacitance.
 - lower the capacitance and breakdown voltage.
 - higher the capacitance.
22. The energy stored in a capacitor is equal to:
- $\frac{1}{2} CV^2$.
 - $\frac{1}{2} VC^2$.
 - Ak/d .
 - Q/V .
23. The breakdown voltage rating of a capacitor is a function of the:
- plate area.
 - capacitance.
 - dielectric material.
 - both a and b.
24. The charge on a capacitor is determined from:
- $Q = V/C$.
 - $C = Q/V$.
 - $C = i\Delta t/V$.
 - $Q = CV$.
25. Two $5 \mu F$, 25V capacitors are wired in series. The equivalent is:
- $2.5 \mu F$, 25V.
 - $2.5 \mu F$, 50V.
 - $10 \mu F$, 25V.
 - $10 \mu F$, 12.5V.
26. When wired into a circuit, a capacitor will:
- block both ac and dc.
 - block ac and pass dc.
 - block dc and pass ac.
 - pass both ac and dc.
27. An ohmmeter connected across a capacitor reads a constant 100 ohms. This indicates a (an):
- shorted capacitor.
 - open capacitor.
 - normal capacitor.
 - faulty ohmmeter.
28. Large value capacitors, from approximately $2 \mu F$ and up:
- have some leakage.
 - are electrolytic types.
 - are polarized.
 - all of the above.
29. A $50 \mu F$, 25V capacitor and a $10 \mu F$, 50V capacitor are wired in parallel. The effective capacitance and working voltage are:
- $60 \mu F$, 75V.
 - $60 \mu F$, 25V.
 - $8.3 \mu F$, 75V.
 - $40 \mu F$, 25V.

21. The higher the constant of a dielectric used in a capacitor, then:
 - a. higher the breakdown voltage rating.
 - b. lower the resistance.
 - c. lower the capacitance and breakdown voltage.
 - d. higher the capacitance.
22. The energy stored in a capacitor is equal to:
 - a. $1/2 CV^2$
 - b. $1/2 VC^2$
 - c. AVd
 - d. QV
23. The breakdown voltage rating of a capacitor is a function of the:
 - a. plate area.
 - b. capacitance.
 - c. dielectric material.
 - d. both a and b.
24. The charge on a capacitor is determined from:
 - a. $Q = VC$
 - b. $C = Q/V$
 - c. $C = Q/V^2$
 - d. $Q = CV$
25. Two 5 μF , 25V capacitors are wired in series. The equivalent is:
 - a. 2.5 μF , 25V
 - b. 10 μF , 25V
 - c. 10 μF , 12.5V
 - d. 2.5 μF , 12.5V
26. When wired into a circuit, a capacitor will:
 - a. block both ac and dc.
 - b. block ac and pass dc.
 - c. block dc and pass ac.
 - d. pass both ac and dc.
27. An ohmmeter connected across a capacitor reads a constant 150 ohms. This indicates a (an):
 - a. shorted capacitor.
 - b. open capacitor.
 - c. normal capacitor.
 - d. leaky capacitor.
28. Large value capacitors have capacitance 1 μF and up:
 - a. four wire lugs.
 - b. are electrolytic types.
 - c. are polarized.
 - d. all of the above.
29. A 50 μF , 25V capacitor and a 10 μF , 25V capacitor are wired in parallel. The effective capacitance and working voltage are:
 - a. 60 μF , 25V
 - b. 60 μF , 12.5V
 - c. 60 μF , 25V
 - d. 60 μF , 12.5V

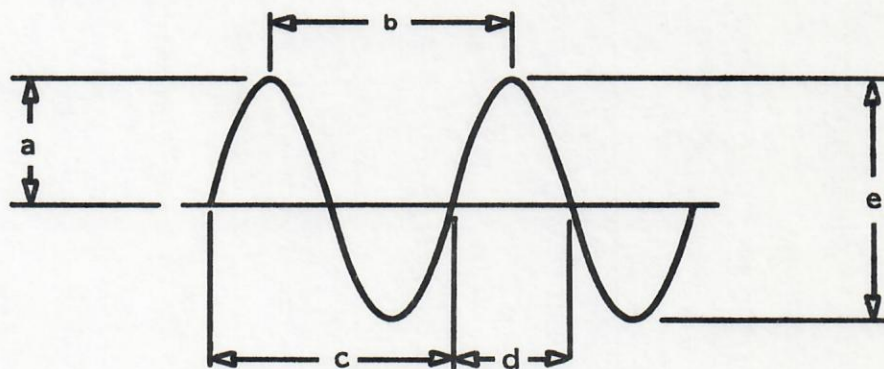
30. The total capacitance and voltage rating, from A to B, for the circuit below, is:



- a. $300\ \mu\text{F}$, 150V . c. $200\ \mu\text{F}$, 50V .
 b. $200\ \mu\text{F}$, 100V . d. $66\ \mu\text{F}$, 100V .

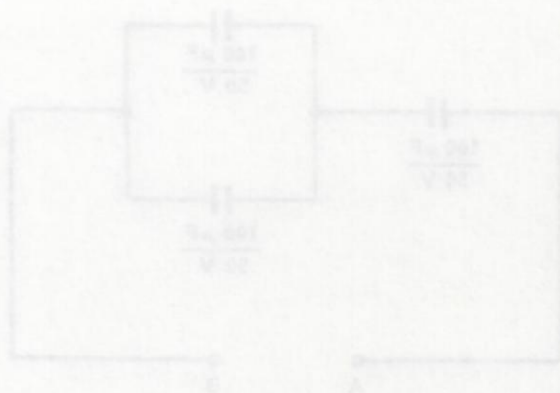
Answer the following matching questions.

31. Match the labeled dimensions in column (A) to those listed in column (B). Some may have more than one definition.



- | (A) | (B) |
|----------|-----------------|
| a. _____ | 1. Alternation |
| b. _____ | 2. Wavelength |
| c. _____ | 3. Period |
| d. _____ | 4. Peak-to-Peak |
| e. _____ | 5. Peak |

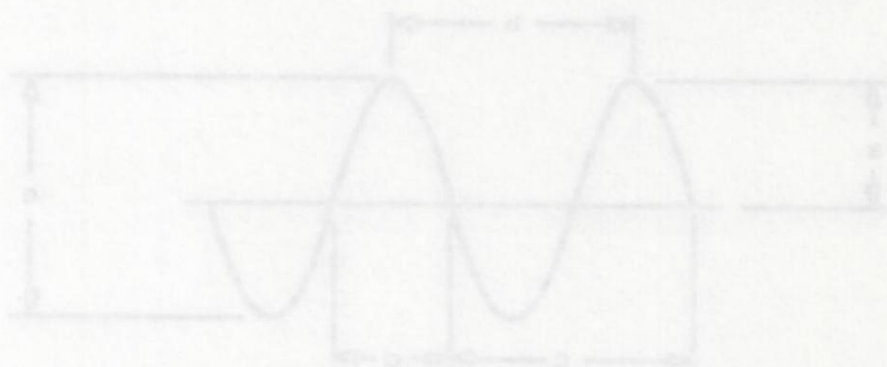
30. The total capacitance and voltage rating from A to B for the circuit below is:



- a. 300 μ F, 25V.
b. 100 μ F, 100V.
c. 300 μ F, 100V.
d. 60 μ F, 100V.

Answer the following matching question.

31. Match the labeled dimensions in column (A) to those listed in column (B). Some may have more than one definition.



- | (A) | (B) |
|----------|-----------------|
| a. _____ | 1. Amplitude |
| b. _____ | 2. Wavelength |
| c. _____ | 3. Period |
| d. _____ | 4. Peak-to-Peak |
| e. _____ | 5. Frequency |

32. Match each waveshape to those listed in column (B).



(a)



(b)



(c)

(A)

a. _____

b. _____

c. _____

(B)

1. Triangle Wave

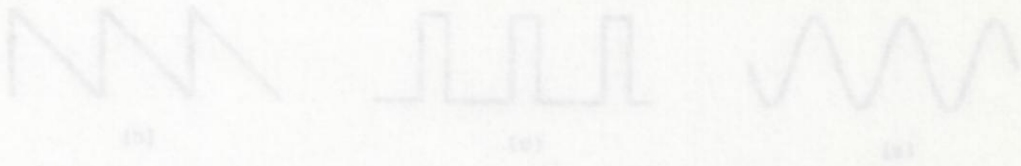
2. Sine Wave

3. Ramp Wave

4. Square Wave

5. Saw Tooth Wave

32. Match each waveform to those listed in column (B).



- | (A) | (B) |
|----------|-------------------|
| 1. _____ | 1. Change Wave |
| 2. _____ | 2. Line Wave |
| 3. _____ | 3. Ramp Wave |
| | 4. Square Wave |
| | 5. Saw Tooth Wave |

NAME _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G1

1. _____ 7. _____ 13. _____ 19. _____ 25. _____

2. _____ 8. _____ 14. _____ 20. _____ 26. _____

3. _____ 9. _____ 15. _____ 21. _____ 27. _____

4. _____ 10. _____ 16. _____ 22. _____ 28. _____

5. _____ 11. _____ 17. _____ 23. _____ 29. _____

6. _____ 12. _____ 18. _____ 24. _____ 30. _____

31. a. _____

b. _____

c. _____

d. _____

e. _____

32. a. _____

b. _____

c. _____

NAME _____ CLASS _____ DATE _____

ANSWER SHEET - QUIZ TEST 01

1.	_____	7.	_____	13.	_____	19.	_____	25.	_____
2.	_____	8.	_____	14.	_____	20.	_____	26.	_____
3.	_____	9.	_____	15.	_____	21.	_____	27.	_____
4.	_____	10.	_____	16.	_____	22.	_____	28.	_____
5.	_____	11.	_____	17.	_____	23.	_____	29.	_____
6.	_____	12.	_____	18.	_____	24.	_____	30.	_____

31.	_____	35.	_____
32.	_____	36.	_____
33.	_____	37.	_____
34.	_____	38.	_____
35.	_____	39.	_____

Unit Test

Part G1—AC Voltages and Components Instructor's Answer Sheet

1. d all of the above.
2. b In an ac power distribution system that covers a large geographical area, the voltage is stepped up for long runs.
3. c It is possible to transmit radio waves between two points when an ac voltage is connected to the antenna.
4. d all of the above.
5. c both a and b.
6. d all of the above.
7. a When the frequency of an ac voltage applied to a lamp is 20 Hz, the lamp will light but flicker.
8. b A dc voltmeter may be used to measure ac voltages when a diode is placed in series with the meter.
9. a The standard range of sound frequencies is considered to be 20 Hz to 20 kHz.
10. d all of the above.
11. b 100 volts.

$$\begin{aligned}e_{\text{inst}} &= E_{\text{peak}} \times \sin \theta \\&= 100 \times \sin 90^\circ \\&= 100 \times 1 = \underline{100V}\end{aligned}$$

12. c 50 Hz.

$$f = 1/T = 1/0.02 = \underline{50 \text{ Hz.}}$$

13. c 2.5 mS.

$$T = 1/f = 1/400 = 0.0025 \text{ S} = \underline{2.5 \text{ mS.}}$$

14. b 141 volts, 282 volts.

$$\begin{aligned}V_{\text{peak}} &= V_{\text{rms}} \times 1.414 \\&= 100 \times 1.414 = \underline{141.4V}\end{aligned}$$

$$V_{\text{p-p}} = 2V_{\text{p}} = (2) 141.4 = \underline{282.8V}$$

2— UNIT TEST FOR PART G1 (ANSWERS)

15. d all of the above.

$$\begin{aligned} \text{a. } V_{\text{peak}} &= V_{\text{rms}} (1.414) = 120 \\ &= 120 (1.414) = \underline{170\text{V.}} \end{aligned}$$

$$\text{b. } V_{\text{p-p}} = 2V_{\text{p}} = (2) 170 = \underline{340\text{V.}}$$

$$\begin{aligned} \text{c. } V_{\text{av}} &= V_{\text{rms}} (0.637) \\ &= 120 (0.637) = \underline{76\text{V.}} \end{aligned}$$

16. c A capacitor may be defined as a component that has two conductors separated by a non-conductor.

17. a A capacitor, when charging, has a high current, initially, which then drops gradually.

18. b In a capacitor that is charging, as one electron enters the negative plate, one electron leaves the positive plate.

19. b As the area of the plates of a capacitor are made larger, the capacity increases.

20. a As the distance separating the capacitor plates is increased, the capacitance will decrease.

21. d The higher the constant of the dielectric used in a capacitor, the higher the capacitance.

22. a The energy stored in a capacitor is equal to $1/2 CV^2$.

23. c The breakdown voltage rating of a capacitor is a function of the dielectric material.

24. d The charge on a capacitor is determined from $Q = CV$.

25. b Two $25 \mu\text{F}$, 25V capacitors are wired in series. This is equivalent to $2.5 \mu\text{F}$ at 50V .

$$C_T = \frac{C_1 C_2}{C_1 + C_2} = \frac{25 \times 25}{25 + 25} = \frac{625}{50} = \underline{12.5 \mu\text{F}}$$

$$\text{Voltage Rating} = V_{C_2} + V_{C_1} = 25 + 25 = \underline{50\text{V}}$$

26. c When wired into a circuit, a capacitor will block dc and pass ac.

27. a An ohmmeter connected across a capacitor reads a constant 100 ohms. This indicates a shorted capacitor.

28. d Large value capacitors, from approximately $2 \mu\text{F}$ and up, have some leakage, are electrolytic types, are polarized.

29. b A 50 μF , 25V capacitor and a 10 μF , 50V capacitor are wired in parallel. The effective capacitance and working voltage are 60 μF , 25V.

30. d $C1//C2 = 100 + 100 = 200 \mu\text{F} @ 50\text{V}$

$$C_T = \frac{(C1)(C2//C3)}{C1 + (C2//C3)} = \frac{(100)(200)}{100 + 200}$$

$$= \frac{20000}{300} = \underline{66.6 \mu\text{F}}$$

31. a. 5
b. 2,3
c. 2,3
d. 1
e. 4

32. a. 2
b. 4
c. 3,5

NAME _____ Marking Key _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G1

1. d 7. a 13. c 19. b 25. b

2. b 8. b 14. b 20. a 26. c

3. c 9. a 15. d 21. d 27. a

4. d 10. d 16. c 22. a 28. d

5. c 11. b 17. a 23. c 29. b

6. d 12. c 18. b 24. d 30. a

31. a. 5

b. 2, 3

c. 2, 3

d. 1

e. 4

32. a. 2

b. 4

c. 3, 5

Unit Test
GZ—AC Components

Unit Test

IX—AC Components

Unit Test

Part G2—AC Components

Answer the following multiple choice questions.

1. Inductance is the ability of an inductor to oppose:
 - a. current flow through it.
 - b. any change in current flow through it.
 - c. a magnetic field.
 - d. a change in voltage across it.
2. The equation for the induced voltage that will appear across an inductor is:
 - a. $L(\Delta i / \Delta T)$
 - b. $L(\Delta T / \Delta i)$
 - c. $T(\Delta i / \Delta L)$
 - d. none of the above.
3. Given that the inductance of a coil is 10 henries and the current changes 2A in 0.5 seconds, the:
 - a. inductor resistance is 5 ohms.
 - b. inductor will overheat due to excessive current.
 - c. induced voltage will be 10V.
 - d. induced voltage will be 40V.
4. Doubling the number of turns on a coil will:
 - a. increase the inductor current rating.
 - b. decrease the inductor resistance.
 - c. increase the inductance by a factor of 2.
 - d. increase the inductance by a factor of 4.
5. Two 10H inductors wired in series, without magnetic coupling between them, will produce a total inductance of:
 - a. 5H.
 - b. 20H.
 - c. less than 5H.
 - d. more than 20H.
6. Two 10H inductors wired in parallel, without magnetic coupling between them, will produce a total inductance of:
 - a. 5H.
 - b. 20H.
 - c. less than 5H.
 - d. more than 20H.
7. The addition of an iron core to an air core coil:
 - a. increases the permeability of the core.
 - b. increases the inductance of the coil.
 - c. may be used to vary the coil inductance value.
 - d. all of the above.

Unit Test

Part II - 40 Components

Answer the following multiple-choice questions.

1. Inductance is the ability of an inductor to oppose:

- a. current flow through it.
- b. any change in current flow through it.
- c. a magnetic field.
- d. a change in voltage across it.

2. The opposition for the induced voltage that will appear across an inductor is:

- a. inductance.
- b. reactance.
- c. resistance.
- d. none of the above.

3. Given that the inductance of a coil is 10 henries and the current changes 2A in 0.5 seconds, then:

- a. induced voltage is 0 ohms.
- b. induced voltage will be 10V.
- c. induced voltage will be 10V.
- d. induced voltage will be 20V.

4. Doubling the number of turns in a coil will:

- a. increase the inductance of the coil.
- b. decrease the inductance of the coil.
- c. increase the inductance by a factor of 2.
- d. decrease the inductance by a factor of 2.

5. Two 10H inductors wired in series, without magnetic coupling between them, will produce a total inductance of:

- a. 20H.
- b. 10H.
- c. less than 10H.
- d. more than 20H.

6. Two 10H inductors wired in parallel, without magnetic coupling between them, will produce a total inductance of:

- a. 20H.
- b. 10H.
- c. less than 10H.
- d. more than 20H.

7. The addition of an iron core to an air core coil:

- a. increases the permeability of the core.
- b. decreases the inductance of the coil.
- c. may be used to vary the coil inductance value.
- d. all of the above.

8. Inductors are rated for their:
- ohmic resistance.
 - maximum allowable current.
 - inductance in H, mH or μH .
 - all of the above.
9. When two coils are positioned at right angles to each other:
- magnetic energy will transfer in one direction only.
 - the coils are tightly coupled.
 - the coils are not coupled.
 - none of the above.

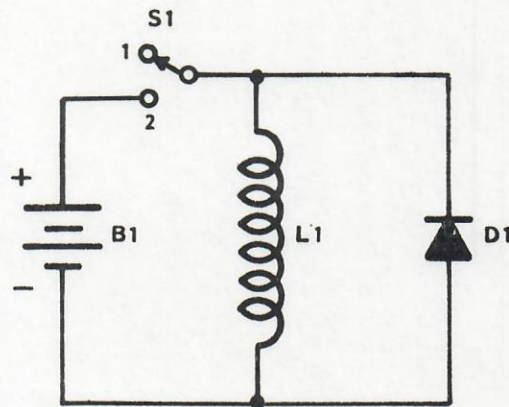


Figure 1 above refers to questions 10 to 12.

10. When switch S1 is first closed in Figure 1, the current flow is limited by the:
- diode, D1.
 - resistance of S1.
 - back emf generated by L1.
 - both b and c.
11. When switch S1 is opened, in Figure 1:
- a large pulse of voltage will appear across L1.
 - the diode will conduct and discharge the energy stored in L1.
 - the maximum voltage across L1 will be V_{B1} , the battery voltage.
 - all of the above.

8. Inductors are rated for their:

- a. ohmic resistance.
- b. maximum allowable current.
- c. inductance in H, mH or μ H.
- d. all of the above.

9. When two coils are positioned at right angles to each other:

- a. magnetic energy will transfer in one direction only.
- b. the coils are tightly coupled.
- c. the coils are not coupled.
- d. none of the above.

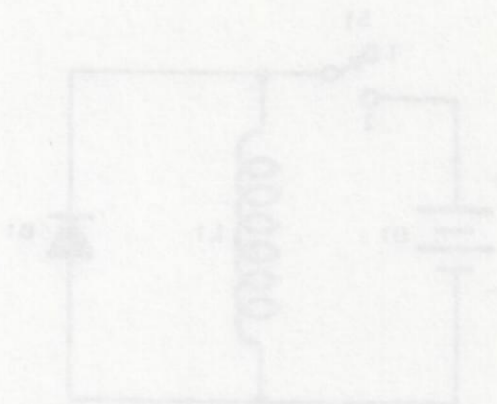


Figure 1 shows refers to questions 10 to 12.

10. When switch S_1 is first closed in Figure 1, the current flow is limited by the:

- a. ohms, R_1 .
- b. resistance of S_1 .
- c. back emf generated by L_1 .
- d. both a and c.

11. When switch S_1 is opened in Figure 1:

- a. a large pulse of voltage will appear across L_1 .
- b. the coils will conduct and discharge the energy stored in L_1 .
- c. the maximum voltage across L_1 will be V_{E1} , the battery voltage.
- d. all of the above.

12. When switch S1, in Figure 1, is closed and then opened, the current waveforms will be:



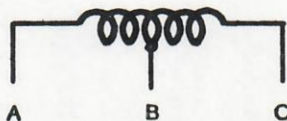
13. In order for an LED to glow, it must be:

- a. forward biased.
- b. reverse biased.
- c. powered by ac only, with a peak voltage of no more than 0.7 volts.
- d. none of the above.

14. The opposition of a coil to the flow of ac through it is called:

- a. inductive resistance.
- b. capacitance resistance.
- c. inductive reactance.
- d. YL.

15. The inductor shown below is center-tapped. Given that the inductance from A to B is 50 mH, the inductance from A to C is:



- a. 25 mH.
- b. 75 mH.
- c. 100 mH.
- d. 200 mH.

16. An inductor when powered by dc, causes a (an):

- a. delay in the current rise when first powered.
- b. opposition to any change in current flow.
- c. dc opposition to the current flow due to wire resistances.
- d. all of the above.

12. When switch S₁ in Figure 1 is closed and then opened, the current waveform will be:



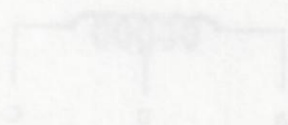
13. In order for an LED to glow, it must be:

- a. forward biased.
- b. reverse biased.
- c. powered by ac only, with a peak voltage of no more than 0.7 volts.
- d. none of the above.

14. The opposition of a coil to the flow of ac through it is called:

- a. inductive reactance.
- b. capacitive reactance.
- c. inductive reactance.
- d. XL.

15. The inductor shown below is center-tapped. Given that the inductance from A to B is 50 mH, the inductance from A to C is:



- a. 100 mH.
- b. 75 mH.
- c. 125 mH.
- d. 200 mH.

16. An inductor when powered by ac, causes a (an):

- a. delay in the current rise when first powered.
- b. opposition to any change in current flow.
- c. no opposition to the current flow due to wire resistance.
- d. all of the above.

17. When an LED is connected to a source of 60 Hz ac voltage, it will:
- a. not light.
 - b. light every half cycle but appear to be on continuously.
 - c. burn out.
 - d. incandesce.
18. A transformer with 100 volts applied to the primary produces 40 volts across the secondary. It has a Turns Ratio of:
- a. 4.
 - b. 100 step down.
 - c. 2.5:1 step down.
 - d. 4:1 step down.
19. A transformer has a primary with 500 turns and a secondary with 40 turns. When 120 volts is applied to the primary, the secondary voltage is:
- a. 1500 volts.
 - b. 9.6 volts.
 - c. 4.16 volts.
 - d. 3 volts.
20. A transformer has 100 volts applied to the primary and develops 20 volts across the secondary. Given a secondary load current of 3 amperes, the primary current is:
- a. 0.5A.
 - b. 3A.
 - c. 5A.
 - d. 6.66A.
21. A transformer has 100 volts applied to the primary and develops 10 volts across the secondary which has a 10 ohm resistor across it. The 100 volt generator sees a primary resistance of:
- a. 10 ohms.
 - b. 100 ohms.
 - c. 1000 ohms.
 - d. 2000 ohms.
22. A transformer is not 100% efficient because of:
- a. I^2R losses.
 - b. Eddy currents.
 - c. Hysteresis losses.
 - d. all of the above.

17. When an LED is connected to a source of 50 Hz ac voltage, it will:

- a. not light.
- b. light every half cycle and appear to be on continuously.
- c. burn out.
- d. illuminate.

18. A transformer with 100 volts applied to the primary produces 20 volts across the secondary. If the primary is:

- a. 100 turns.
- b. 1000 turns.
- c. 2000 turns.
- d. 200 turns.

19. A transformer has a primary with 500 turns and a secondary with 20 turns. When 120 volts is applied to the primary, the secondary voltage is:

- a. 1200 volts.
- b. 24 volts.
- c. 4.8 volts.
- d. 2.4 volts.

20. A transformer has 100 volts applied to the primary and develops 10 volts across the secondary. Given a secondary load current of 2 amperes, the primary current is:

- a. 0.2 A.
- b. 2 A.
- c. 0.02 A.
- d. 20 A.

21. A transformer has 100 volts applied to the primary and develops 10 volts across the secondary which has a 10 ohm resistor across it. The 100 volt generator sees a primary impedance of:

- a. 10 ohms.
- b. 100 ohms.
- c. 1000 ohms.
- d. 2000 ohms.

22. A transformer is not 100% efficient because of:

- a. I²R losses.
- b. Eddy currents.
- c. Hysteresis losses.
- d. all of the above.

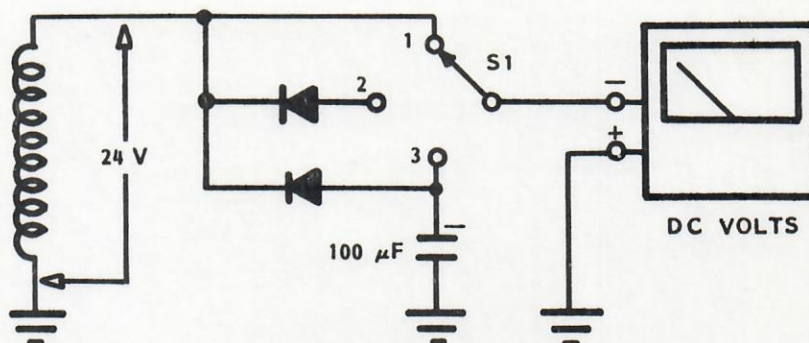


Figure 2 above refers to questions 23 to 25.

23. In Figure 2, with switch S1 in position 1, the meter will read:
- zero volts.
 - 15 volts, average.
 - 24 volts, rms.
 - 34 volts peak.
24. In Figure 2, with switch S1 in position 2, the meter will read:
- 10.8 volts.
 - 21.6 volts.
 - 24 volts.
 - none of the above.
25. In Figure 2, with switch S1 in position 3, the meter will read:
- 10.8 volts.
 - 21.6 volts
 - 24 volts.
 - 34 volts.

CIRCUIT SYMBOL DRAWINGS

26. Draw the following circuit symbols in the spaces provided.
- Air core coil.
 - Laminated iron core coil.
 - Powered iron core coil.
 - Variable core tuned inductor.
 - Variable autotransformer.
 - Transformer with center-tapped secondary.
 - Diode symbol labelling Anode and Cathode.
 - A dc meter wired to read peak ac.

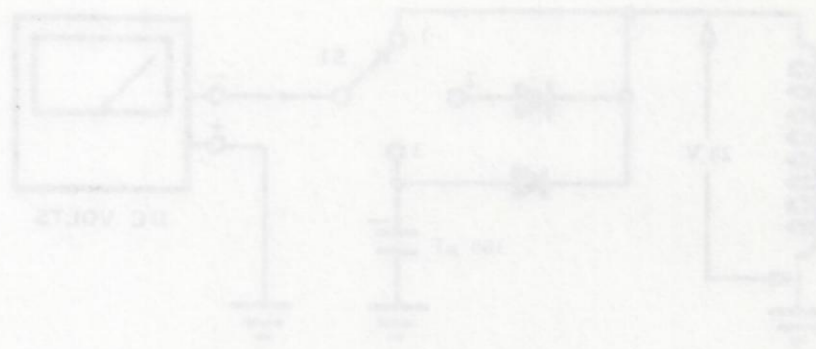


Figure 1 above refers to questions 23 to 25.

23. In Figure 1, with switch S1 in position 1, the meter will read:

- a. zero volts.
- b. 15 volts, average.
- c. 25 volts, rms.
- d. 25 volts peak.

24. In Figure 1, with switch S1 in position 2, the meter will read:

- a. 10.6 volts.
- b. 21.6 volts.
- c. 25 volts.
- d. none of the above.

25. In Figure 1, with switch S1 in position 2, the meter will read:

- a. 10.6 volts.
- b. 21.6 volts.
- c. 25 volts.
- d. 25 volts.

CIRCUIT SYMBOL DEFINITIONS

26. Draw the following circuit symbols in the spaces provided:

- a. Air core coil.
- b. Laminated iron core coil.
- c. Powdered iron core coil.
- d. Variable core tuned inductor.
- e. Variable autotransformer.
- f. Transformer with center-tapped secondary.
- g. Valve symbol including Anode and Cathode.
- h. A diode symbol with peak to peak ac.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G2

1. _____ 6. _____ 11. _____ 16. _____ 21. _____

2. _____ 7. _____ 12. _____ 17. _____ 22. _____

3. _____ 8. _____ 13. _____ 18. _____ 23. _____

4. _____ 9. _____ 14. _____ 19. _____ 24. _____

5. _____ 10. _____ 15. _____ 20. _____ 25. _____

26. a.

b.

c.

d.

e.

f.

g.

h.

ANSWER SHEET—UNIT TEST 01

1.	_____	_____	_____	_____	_____
2.	_____	_____	_____	_____	_____
3.	_____	_____	_____	_____	_____
4.	_____	_____	_____	_____	_____
5.	_____	_____	_____	_____	_____

20. a. _____

b. _____

c. _____

d. _____

Unit Test
Part G2—AC Components
Instructor's Answer Sheet

1. b Inductance is the ability of a component to oppose any change in current flow through it.
2. a The equation for the induced voltage that will appear across an inductor, is $L(\Delta i/\Delta T)$.
3. d Given that the inductance of a coil is 10 henries and the current through it changes 2A in 0.5 seconds, the induced voltage will be 40 volts.

$$e_{\text{ind}} = L \frac{\Delta i}{\Delta T} = 10 \frac{2}{0.5} = \underline{40 \text{ V}}$$

4. d Doubling the number of turns on a coil will increase the inductance by a factor of 4.
5. b 20 mH.

For series inductors:

$$\begin{aligned} L_T &= L_1 + L_2 \\ &= 10 + 10 = \underline{20 \text{ mH}} \end{aligned}$$

6. a 5 H

For parallel inductors:

$$\begin{aligned} L_T &= \frac{(L_1) (L_2)}{L_1 + L_2} \\ &= \frac{(10) (10)}{10 + 10} = \underline{5 \text{ H}} \end{aligned}$$

7. d all of the above.
8. d all of the above.
9. c When two coils are positioned at right angles to each other, the coils are not coupled.
10. c When switch S1 is first closed in Figure 1, the current flow is limited by the back emf generated by L1.
11. b When switch S1 is opened, the diode will conduct and discharge the energy stored in L1.

2 — UNIT TEST FOR PART G2 (ANSWERS)

12. c  collapsing field drained by D1.

13. a In order for an LED to glow, it must be forward biased.

14. c The opposition of a coil to the flow of ac through it is called inductive reactance.

15. d 200 mH.

$$L = \frac{N^2 \mu R^2}{\ell}$$

where N is the number of coil turns. Doubling N and squaring it results in a fourfold increase in L or $50 \times 4 = \underline{200 \text{ mH.}}$

16. d all of the above.

17. b When an LED is connected to a source of 60 Hz ac, it will light every half cycle but appear to be on continuously.

18. c 2.5:1 step down

$$T_R = \frac{e_p}{e_s} = \frac{100}{40} = \underline{2.5:1 \text{ step down}}$$

19. b 9.6 volts

$$e_s = e_p \frac{N_s}{N_p}$$

$$e_s = (120) \frac{40}{500} = \underline{9.6 \text{ volts}}$$

20. a 0.5A

$$\frac{I_s}{I_p} = \frac{V_p}{V_s} \quad \frac{3}{I_p} = \frac{120}{20}$$

$$60 = 120 I_p \quad I_p = \frac{60}{120} = \underline{0.5A}$$

21. c 1K

$$R_{in} = (R_L) TR^2 = 10 \left(\frac{100}{10} \right)^2 = \underline{1,000 \text{ ohms}}$$

22. d all of the above.

23. a zero volts

A dc meter will not read ac voltage.

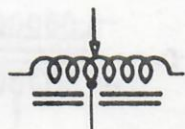
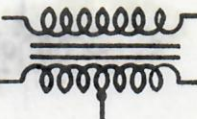
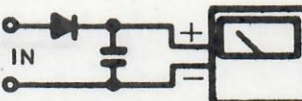
24. a 10.8 volts

For half wave, the average voltage is:

$$\begin{aligned} V_{av} &= 0.45 V_{rms} \\ &= 0.45(24) = \underline{10.8 \text{ volts}} \end{aligned}$$

25. d 34 voltsThe 100 μ F capacitor will charge to peak.

$$\begin{aligned} V_{pk} &= V_{rms} (1.414) \\ &= 24(1.414) = \underline{33.94 \text{ volts}} \end{aligned}$$

26. a. b. c.  OR d.  OR e. f. g. h. 

NAME _____ Marking Key _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G2

1. b 6. a 11. b 16. d 21. c

2. a 7. d 12. c 17. b 22. d

3. d 8. d 13. a 18. c 23. a

4. d 9. c 14. c 19. b 24. a

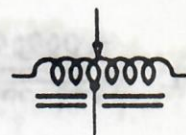
5. b 10. d 15. d 20. a 25. d

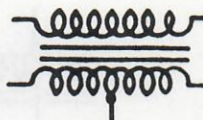
26. a. 

b. 

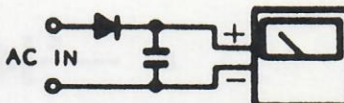
c.  OR 

d.  OR 

e. 

f. 

g. 

h. 

Unit Test

G3—AC Oscilloscope Operations and Applications

Unit Test

ED—AC Oscilloscope Operations
and Applications

Unit Test

Part G3—AC Oscilloscope Operations and Applications

Answer the following multiple choice questions.

1. The cathode ray tube in an oscilloscope:
 - a. is often called a crt.
 - b. is a vacuum tube.
 - c. moves the electron beam by electrostatic forces.
 - d. all of the above.
2. The electron beam in a cathode ray tube is formed by the:
 - a. electron gun.
 - b. fluorescent coating.
 - c. vacuum.
 - d. electron deflection plates.

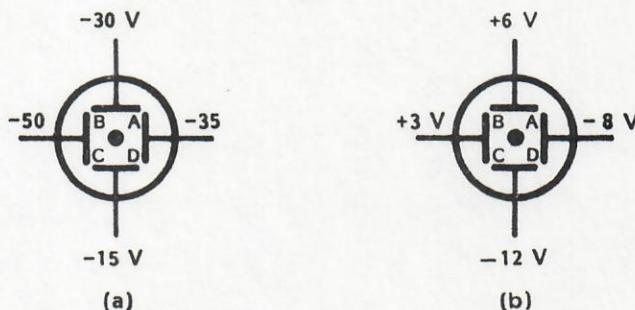


Figure 1 above refers to questions 3 to 5.

3. In (a) of Figure 1, the electron beam that is moving down the neck of the crt will appear on the screen at point:
 - a. A.
 - b. B.
 - c. C.
 - d. D.
4. In (b) of Figure 1, the electron beam will appear on the screen, at point:
 - a. A.
 - b. B.
 - c. C.
 - d. D.
5. In Figure 1(a), to move the beam from its present position to D, it is necessary to change:
 - a. -50 volts to +50 volts.
 - b. -15 volts to +15 volts.
 - c. -30 volts to + 30 volts.
 - d. nothing; the beam is there.

Unit Test

Part 2--60 Cathode-ray Oscilloscope Questions and Applications

Answer the following multiple-choice questions.

1. The cathode ray tube in an oscilloscope:
 - a. is often called a CRT.
 - b. is a vacuum tube.
 - c. moves the electron beam by electrostatic forces.
 - d. all of the above.
2. The electron beam in a cathode ray tube is focused by:
 - a. electron gun.
 - b. fluorescent coating.
 - c. electron deflection plates.
 - d. electron gun.



Figure 1 above refers to questions 3 to 5.

3. In (a) of Figure 1, the electron beam that is moving down the neck of the CRT will appear on the screen at:
 - a. A.
 - b. B.
 - c. C.
 - d. D.
4. In (b) of Figure 1, the electron beam will appear on the screen at point:
 - a. A.
 - b. B.
 - c. C.
 - d. D.
5. In Figure 1(a), to move the beam from its present position to D, it is necessary to change:
 - a. -50 volts to +50 volts.
 - b. -15 volts to +15 volts.
 - c. -50 volts to +50 volts.
 - d. nothing; the beam is there.

UNIT TEST FOR PART G3-2

6. For waveform observation on the oscilloscope, the horizontal deflection waveform must be a:
 - a. ramp voltage.
 - b. sine wave.
 - c. square wave.
 - d. any of the above.

7. When a sine wave is applied to the vertical deflection plates and there is no horizontal deflection, the screen display will be a:
 - a. horizontal line.
 - b. vertical line.
 - c. sine wave.
 - d. line at a 45° angle.

8. The higher the frequency of the oscilloscope horizontal sweep, for a given vertical input:
 - a. more cycles will appear on the screen.
 - b. fewer cycles will appear on the screen.
 - c. the number of cycles that appear are unchanged.
 - d. the waveshapes will change from sine to square or square to sine.

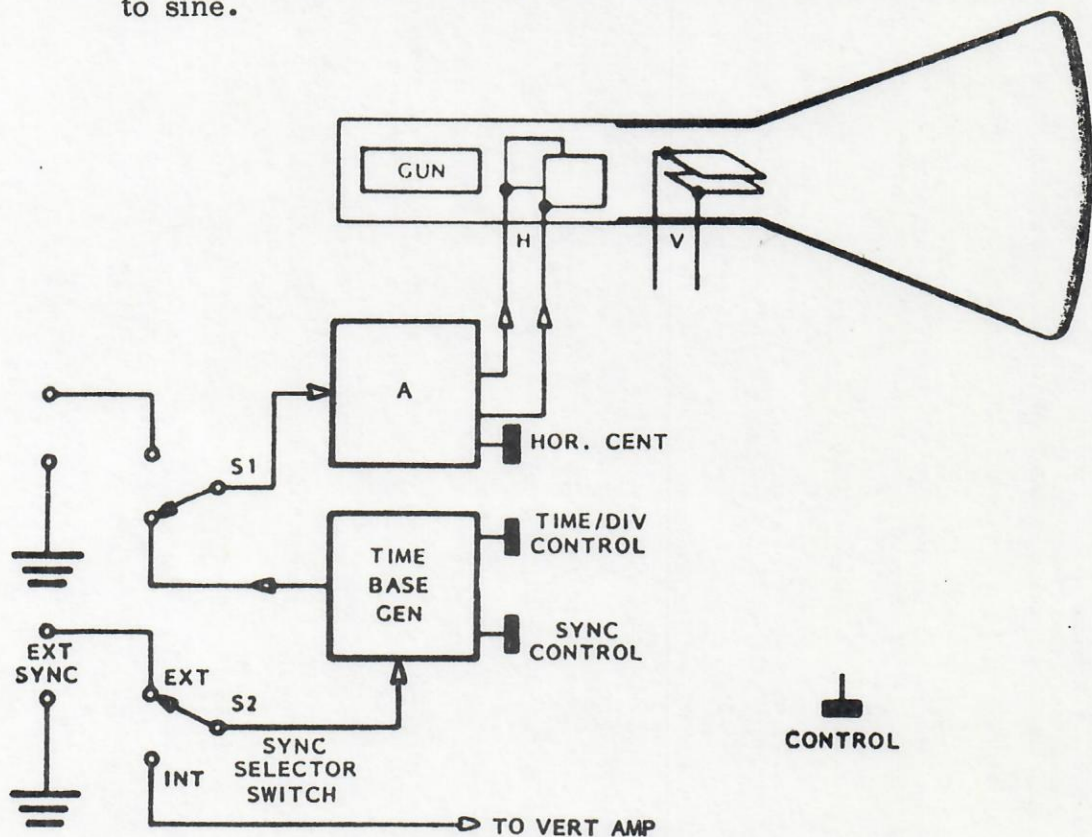


Figure 2 above refers to questions 9 to 11.

9. The entire block diagram in Figure 2 is identified as the:
 - a. vertical sweep system.
 - b. synchronizing system.
 - c. horizontal sweep system.
 - d. switching system.

6. For a vertical observation on the oscilloscope, the horizontal deflection waveform must be a

- step voltage.
- sine wave.
- any of the above.
- none of the above.

7. When a sine wave is applied to the vertical deflection plates and there is no horizontal deflection, the screen display will be a

- horizontal line.
- vertical line.
- line at 45° angle.
- none of the above.

8. The higher the frequency of the modulating horizontal sweep, for a given vertical input,

- more cycles will appear on the screen.
- fewer cycles will appear on the screen.
- the number of cycles that appear are unchanged.
- the waveforms will change from sine to square or square to sine.

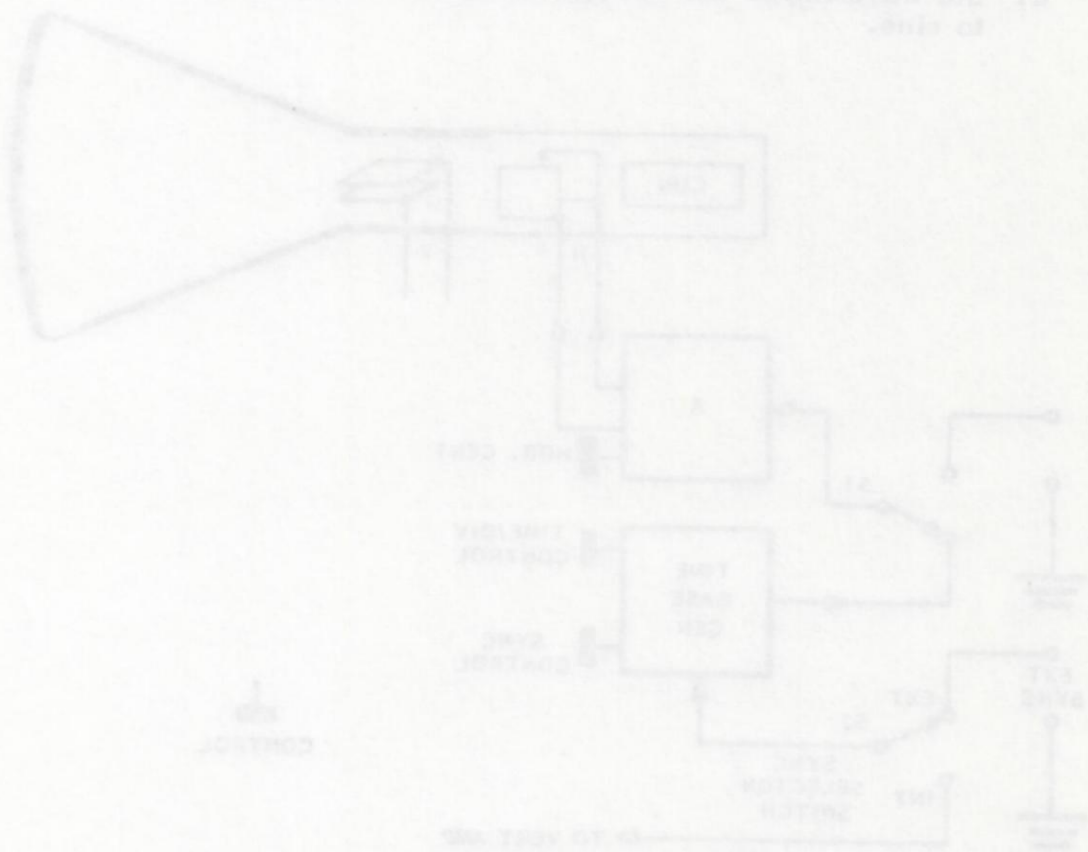
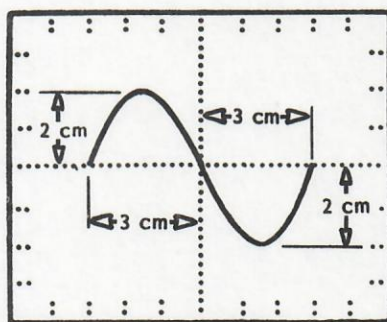


Figure 1 shows refers to questions 9 to 11.

9. The entire block diagram in Figure 2 is identified as the:

- vertical sweep system.
- horizontal sweep system.
- horizontal sweep system.
- vertical sweep system.

10. Block A in Figure 2 represents the:
- time base generator.
 - horizontal amplifier.
 - synchronization amplifier.
 - vertical amplifier.
11. The function of switch S1 in Figure 2 is to switch between:
- internal and external vertical sweep.
 - internal and external horizontal sweep.
 - sources of synchronization signals.
 - the vertical amplifier and the horizontal amplifier.



CONTROL SETTINGS

CH 1	=	5 V/DIV
TIME/DIV	=	50 μ S
SYCH	=	CH 1
CH 2	=	INVERT

Figure 3 above refers to questions 12 and 13.

12. The display shown in Figure 3 for the control conditions listed has a (an):
- p-p voltage of 20 volts and a frequency of 33 kHz.
 - rms voltage of 10 volts and a period of 25 μ S.
 - effective voltage of 7 volts and a period of 0.3 mS.
 - average voltage of 12.7 and a frequency of 3.33 kHz.
13. If the vertical input probe is set on $\times 10$, the actual peak-to-peak voltage displayed on the screen in Figure 3 is:
- 200 volts peak-to-peak.
 - 20 volts peak-to-peak.
 - 2 volts peak-to-peak.
 - none of the above.
14. When observing a waveform, the VOLTS/DIV switch controls the:
- display width.
 - number of cycles displayed.
 - sync source.
 - display height.

10. Block A in Figure 7 represents the:

- a. the base generator.
- b. horizontal amplifier.
- c. synchronization amplifier.
- d. vertical amplifier.

11. The function of switch S1 in Figure 7 is to switch between:

- a. internal and external vertical sweep.
- b. internal and external horizontal sweep.
- c. sources of synchronization signals.
- d. the vertical amplifier and the horizontal amplifier.

CONTROL SETTINGS

CH 1 = 2 V/DIV

TIMEBASE = 10 μ s

CH 2 = CH 1

CH 3 = INVERT

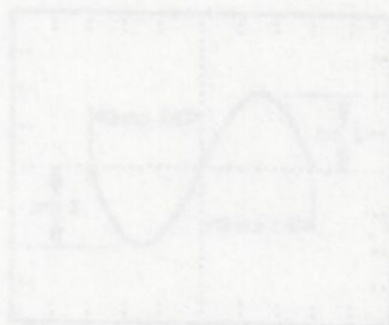


Figure 7 shows waveforms for questions 10 and 11.

12. The display shown in Figure 8 for the external synchronization input has a:

- a. p-p voltage of 10 volts and a frequency of 25 kHz.
- b. rms voltage of 10 volts and a period of 15 μ s.
- c. effective voltage of 7 volts and a period of 0.5 ms.
- d. average voltage of 1.5 V and a frequency of 2.5 kHz.

13. If the vertical most probe is set on 10, the actual peak-to-peak voltage displayed on the screen in Figure 8 is:

- a. 100 volts peak-to-peak.
- b. 10 volts peak-to-peak.
- c. 2 volts peak-to-peak.
- d. none of the above.

14. When observing a waveform, the VOLTS/DIV switch controls the:

- a. display width.
- b. number of graticles displayed.
- c. sync source.
- d. display height.

15. The bright horizontal line that appears on the crt screen of an oscilloscope is the:

- a. free running trace.
- b. display but the TIME/DIV is set much too high.
- c. result when the Input Switch is set to GND.
- d. all of the above.

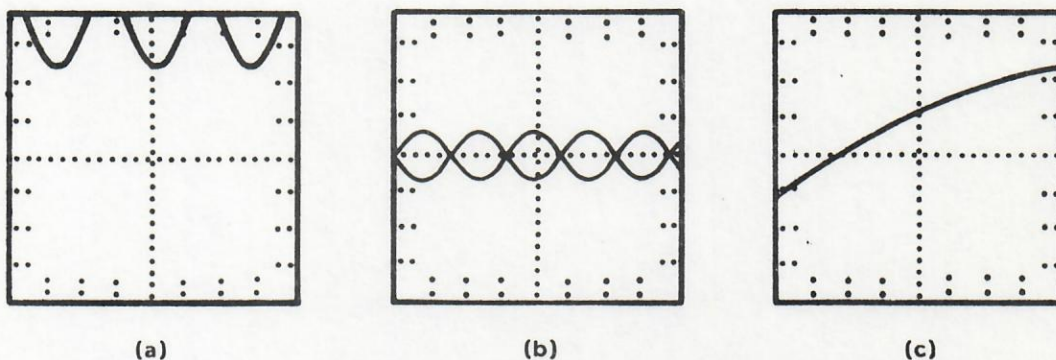


Figure 4 above refers to questions 16 to 18.

16. Display (a) in Figure 4 indicates:

- a. vertical centering set too low.
- b. vertical centering set too high.
- c. horizontal sync misadjusted.
- d. excessive vertical gain.

17. Display (b) in Figure 4 is most likely due to an improperly set:

- a. Vertical Input Switch.
- b. Vertical VOLTS/DIV Switch.
- c. Trigger control.
- d. any of the above.

18. Display (c) in Figure 4 is caused by:

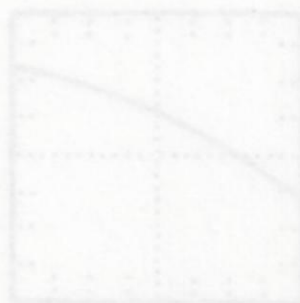
- a. too high a horizontal sweep frequency.
- b. insufficient horizontal gain.
- c. insufficient vertical sweep.
- d. a low internal sweep frequency.

19. A dual trace oscilloscope can:

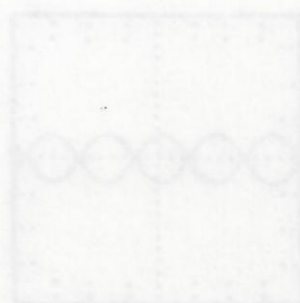
- a. display two separate signals on one screen.
- b. measure the phase difference between two signals.
- c. compare input and output signals from a circuit.
- d. all of the above.

12. The bright horizontal line that appears on the CRT screen of an oscilloscope is the

- trace of the signal.
- display of the TIME DIV is not much too high.
- control when the input section is set to GND.
- all of the above.



(a)



(b)



(c)

Figure 1 shows refers to questions 14 to 16.

14. Display (a) in Figure 1 indicates

- vertical centering set too low.
- vertical centering set too high.
- horizontal sync established.
- excessive vertical gain.

15. Display (b) in Figure 1 is most likely due to an

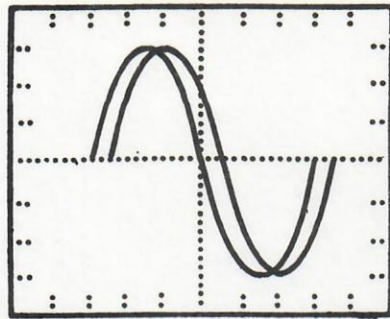
- Vertical Input Switch.
- Vertical Variable Switch.
- Trigger control.
- any of the above.

16. Display (c) in Figure 1 is caused by

- too high a horizontal sweep frequency.
- insufficient horizontal gain.
- insufficient vertical sweep.
- a low internal sweep frequency.

17. A dual trace oscilloscope can

- display two separate signals on one screen.
- measure the phase difference between two signals.
- compare input and output signals from a circuit.
- all of the above.

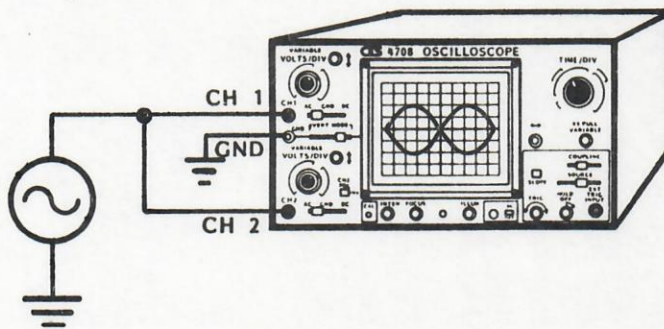
CONTROL SETTINGS

V/DIV = 5 V

TIME/DIV = 20 μ S

Figure 5 above refers to question 20.

20. The display in Figure 5 indicates a(an):
- rms voltage of 15 volts peak and a period of 130 μ S.
 - peak voltage of 15 volts and a phase difference of 30 degrees.
 - rms voltage of 10.6 volts and a phase shift of 60 degrees.
 - none of the above.

CONTROL SETTINGS

CH 1,2 V/DIV = 5

VERT MODE = DUAL

Figure 6 above refers to question 21.

21. The display shown in Figure 6 is caused by a:
- depressed CH 2 INVERT switch.
 - misadjusted CH 1 Input Switch.
 - sync selection control set for LINE FREQ.
 - any of the above.
22. A waveform has a period of 40 μ S and the TIME/DIV switch is set at 20 μ S/division. When the x5 magnifier is turned on, the display will:
- cover the full 10 divisions horizontally.
 - expand vertically.
 - shrink to a narrow vertical line 8 μ S wide.
 - none of the above.

CONTROL SETTINGS
 VOLT = 1 V
 TIME DIV = 10 ns

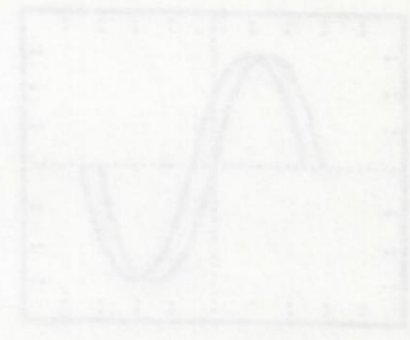


Figure 3 shows waveforms in question 12.

12. The display in Figure 3 represents:
 - a. two waveforms of 10 volts peak and a period of 100 ns.
 - b. peak voltage of 10 volts and a phase difference of 180 degrees.
 - c. two waveforms of 100 volts and a phase shift of 180 degrees.
 - d. none of the above.

CONTROL SETTINGS
 CH 1 VOLT = 1
 VERT MODE = DUAL



Figure 4 shows waveforms in question 11.

11. The display shown in Figure 4 is caused by:
 - a. depressed CH 1 TRIGGER switch.
 - b. depressed CH 1 INPUT switch.
 - c. sync selection control on the LINE TRIG.
 - d. any of the above.
13. A waveform has a period of 50 ns and the TRIGGER switch is set at 10 divisions. When the 10 marker is turned on, the display will:
 - a. cover the full 10 divisions horizontally.
 - b. expand vertically.
 - c. appear to a narrow vertical line 5 ns wide.
 - d. none of the above.

23. The CHOP mode of dual trace operation:
- can cause gaps to appear in the displayed waveforms.
 - can cause the display to jump up and down at the sweep rate.
 - is usually superior to the Alternate mode.
 - is no different than the Alternate mode and are used interchangeably.
24. When the ADD function of the vertical mode switch is selected, the CH1 and CH2 waveforms, each 5 volts p-p, are added:
- and the frequency difference appears on the screen.
 - for a 15 volt p-p display.
 - algebraically.
 - all of the above.
25. A dual trace oscilloscope can be used to measure:
- phase differences between two signals.
 - time intervals between two signals.
 - dc voltages.
 - all of the above.
26. The ac scale calibration on a volt-ohmmeter (VOM), unless otherwise noted, is in:
- 60 Hz.
 - rms volts.
 - peak volts.
 - peak-to-peak volts.
27. The ac scale markings on a volt-ohmmeter (VOM) are correct for:
- sine waves.
 - triangular waves.
 - square waves.
 - all of the above.
28. The correct equation to calculate the peak voltage of an oscilloscope screen display is:
- $$\frac{(\text{VOLTS/DIV})(\text{No. of Vert Div})}{\text{Probe Setting}}$$
 - $$\frac{(\text{VOLTS/DIV})(\text{No. of Horiz Div})}{\text{Probe Setting (2)}}$$
 - $$\frac{(\text{VOLTS/DIV})(\text{No. of Vert Div})(\text{Probe Setting})}{2}$$
 - none of the above.

28. The CHOP mode of dual trace operation:
 - a. can cause gaps to appear in the displayed waveform.
 - b. can cause the display to jump up and down at the sweep rate.
 - c. is usually superior to the alternate mode.
 - d. is no different than the alternate mode and are used interchangeably.
29. When the ADD function of the vertical mode switch is selected, the CH1 and CH2 waveforms, each 2 volts p-p, are added:
 - a. and the resulting difference appears on the screen.
 - b. for a 15 volt p-p display.
 - c. algebraically.
 - d. all of the above.
30. A dual trace oscilloscope can be used to measure:
 - a. phase difference between two signals.
 - b. time intervals between two signals.
 - c. no voltage.
 - d. all of the above.
31. The ac noise calibration on a volt-ohmmeter (VOM), unless otherwise noted, is in:
 - a. 60 Hz.
 - b. rms volts.
 - c. peak volts.
 - d. peak-to-peak volts.
32. The ac noise readings on a volt-ohmmeter (VOM) are correct for:
 - a. pure wave.
 - b. resistance wave.
 - c. square wave.
 - d. all of the above.
33. The correct equation to estimate the peak voltage of an oscilloscope screen display is:

$$\frac{\text{VOLTS/DIV}(\text{No. of Vert Divs})}{\text{Probe Setting}}$$
 - a.
 - b. $\frac{\text{VOLTS/DIV}(\text{No. of Horiz Divs})}{\text{Probe Setting (X)}}$
 - c. $\frac{\text{VOLTS/DIV}(\text{No. of Vert Divs})}{\text{Probe Setting}}$
 - d. none of the above.

29. The frequency of a square wave, given a period of 50 microseconds is closest to:
- a. 20 Hz.
 - b. 400 Hz.
 - c. 10 kHz.
 - d. 20 kHz.
30. In an RC circuit, to lengthen the time constant it is necessary to:
- a. increase C.
 - b. increase R.
 - c. increase either C or R.
 - d. all of the above.
31. The time constant of an RC circuit is equal to:
- a. R/C .
 - b. $(R)(C)$.
 - c. C/R .
 - d. $R-C$.
32. A capacitor is placed across a 100 volt source. In one TC the capacitor will charge to:
- a. 20.5 volts.
 - b. 50.75 volts.
 - c. 63.2 volts.
 - d. 100 volts.
33. A capacitor is considered to be fully charged after:
- a. being connected to the source.
 - b. 5 time constants.
 - c. 3 time constants.
 - d. 1 time constant.
34. The time constant of a series RL circuit is equal to:
- a. R/L .
 - b. $(R)(L)$.
 - c. L/R .
 - d. $R-L$.
35. Given a 5K resistor and a 100 μ F capacitor, the series combination will provide a time constant of:
- a. 0.5 seconds.
 - b. 95 milliseconds.
 - c. 0.05×10^9 seconds.
 - d. 20×10^{-9} seconds.
36. An RL circuit consisting of a 2K resistor in series with a 3H inductor produces a time constant of:
- a. 6000 mS.
 - b. 6000 μ S.
 - c. 0.0015 S.
 - d. none of the above.
37. The addition of an iron core to an air core inductor:
- a. increase the inductance.
 - b. changes the relationship between B and H.
 - c. increases the coil Q.
 - d. all of the above.

29. The frequency of a square wave, given a period of 10 microseconds is closest to:

- a. 10 Hz.
- b. 100 Hz.
- c. 10 kHz.
- d. 10 MHz.

30. In an RC circuit, to lengthen the time constant it is necessary to:

- a. increase C.
- b. increase R.
- c. increase either C or R.
- d. all of the above.

31. The time constant of an RC circuit is equal to:

- a. R/C .
- b. $(R/C)^2$.
- c. C/R .
- d. $R \cdot C$.

32. A capacitor is placed across a 100 volt source. In one TC the capacitor will charge to:

- a. 20.5 volts.
- b. 36.8 volts.
- c. 63.2 volts.
- d. 100 volts.

33. A capacitor is considered to be fully charged after:

- a. being connected to the source.
- b. 5 time constants.
- c. 3 time constants.
- d. 1 time constant.

34. The time constant of a series RC circuit is equal to:

- a. $R \cdot C$.
- b. C/R .
- c. R/C .
- d. $R + C$.

35. Given a 50 resistor and a 100 nF capacitor, the series combination will provide a time constant of:

- a. 0.5 seconds.
- b. 50 milliseconds.
- c. 5.0×10^{-5} seconds.
- d. 5.0×10^{-6} seconds.

36. An RC circuit consisting of a 10 resistor in series with a 20 inductor produces a time constant of:

- a. 2000 nS.
- b. 200 nS.
- c. 2000 S.
- d. none of the above.

37. The addition of an inductor to an RC network:

- a. increases the inductance.
- b. changes the relationship between R and C.
- c. increases the RC.
- d. all of the above.

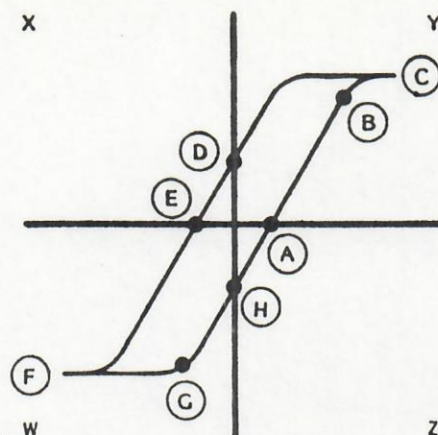


Figure 7 above refers to questions 38 to 40.

38. Figure 7 represents an X-Y plot of the behavior of a (an):
- diode.
 - inductor.
 - capacitor.
 - RC combination.
39. Point F in Figure 7 represents:
- negative saturation.
 - retentivity, B_r .
 - negative coercivity.
 - none of the above.
40. Point E in Figure 7 represents:
- positive saturation.
 - retentivity, B_r .
 - negative coercivity.
 - none of the above.
41. One side of the power line is grounded just before it enters a building in order to:
- compensates for ground loops.
 - reduce shock hazards.
 - protect against the effects of a lightning strike.
 - all of the above.
42. The standard house wiring color code is Black _____ ; Green _____ ; White _____ .
- hot; ground; neutral.
 - neutral; hot; ground.
 - ground; neutral; hot.
 - ground; hot; neutral.

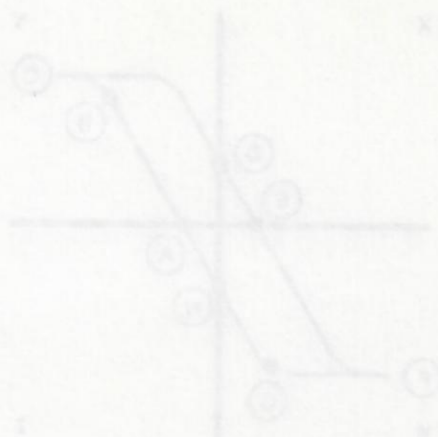


Figure 1 shows refers to questions 35 to 40.

35. Figure 1 represents an X-Y plot of the behavior of a (n):

- a. diode.
- b. resistor.
- c. capacitor.
- d. AC condenser.

36. Point 1 in Figure 1 represents:

- a. negative saturation.
- b. zero resistance.
- c. negative resistance.
- d. zero of the slope.

37. Point 2 in Figure 1 represents:

- a. positive saturation.
- b. zero resistance.
- c. negative resistance.
- d. zero of the slope.

38. One side of the power line is grounded just before it enters a building in order to:

- a. compensate for ground loops.
- b. reduce shock hazard.
- c. protect against the effects of a lightning strike.
- d. all of the above.

39. The standard names which apply to these _____ are _____.

- a. hot; ground; neutral.
- b. neutral; hot; ground.
- c. ground; neutral; hot.
- d. ground; hot; neutral.

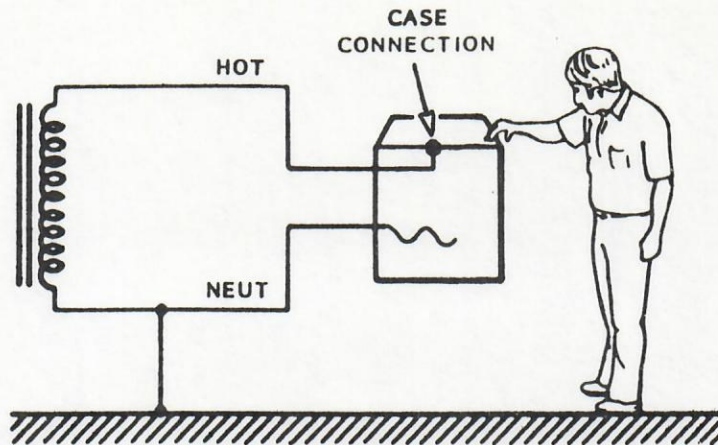


Figure 8 above refers to questions 43 and 44.

43. The person shown in Figure 8:
 - a. cannot receive a shock because he is firmly grounded.
 - b. is receiving a possibly lethal shock.
 - c. will receive no more than a slight shock.
 - d. none of the above.
44. The person shown in Figure 8:
 - a. is in danger of being electrocuted.
 - b. could be saved from a shock by switching the hot and neutral wires.
 - c. could be protected by grounding the case with a third wire.
 - d. all of the above.
45. Unintended ground loops formed by connecting several pieces of equipment together, can:
 - a. produce erroneous meter readings.
 - b. short out signal lines.
 - c. both (a) and (b).
 - d. neither (a) nor (b).

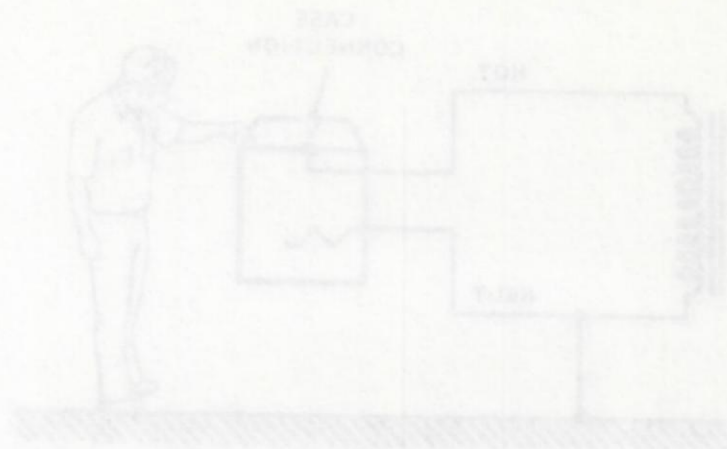


Figure 2 above refers to questions 41 and 42.

41. The person shown in Figure 2:
- is not wearing a safety harness or is likely grounded.
 - is wearing a possibly lethal shock.
 - will receive no more than a slight shock.
 - none of the above.
42. The person shown in Figure 2:
- is in danger of being electrocuted.
 - could be saved from a shock by releasing the hot and neutral wires.
 - could be protected by grounding the case with a third wire.
 - all of the above.
43. Uninsulated ground loops formed by connecting several pieces of equipment together, can:
- produce secondary noise signals.
 - short out signal lines.
 - both (a) and (b).
 - neither (a) nor (b).

NAME _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G3

- | | | | | |
|----------|-----------|-----------|-----------|-----------|
| 1. _____ | 10. _____ | 19. _____ | 28. _____ | 37. _____ |
| 2. _____ | 11. _____ | 20. _____ | 29. _____ | 38. _____ |
| 3. _____ | 12. _____ | 21. _____ | 30. _____ | 39. _____ |
| 4. _____ | 13. _____ | 22. _____ | 31. _____ | 40. _____ |
| 5. _____ | 14. _____ | 23. _____ | 32. _____ | 41. _____ |
| 6. _____ | 15. _____ | 24. _____ | 33. _____ | 42. _____ |
| 7. _____ | 16. _____ | 25. _____ | 34. _____ | 43. _____ |
| 8. _____ | 17. _____ | 26. _____ | 35. _____ | 44. _____ |
| 9. _____ | 18. _____ | 27. _____ | 36. _____ | 45. _____ |

NAME

CLASS

DATE

PHYSICS SHEET—UNIT TEST 31

1.	_____	_____	_____	_____	_____
2.	_____	_____	_____	_____	_____
3.	_____	_____	_____	_____	_____
4.	_____	_____	_____	_____	_____
5.	_____	_____	_____	_____	_____
6.	_____	_____	_____	_____	_____
7.	_____	_____	_____	_____	_____
8.	_____	_____	_____	_____	_____
9.	_____	_____	_____	_____	_____
10.	_____	_____	_____	_____	_____

Unit Test

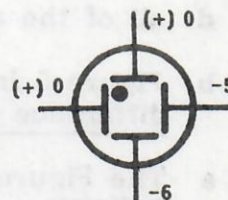
Part G3—AC Oscilloscope Operations and Applications

Instructor's Answer Sheet

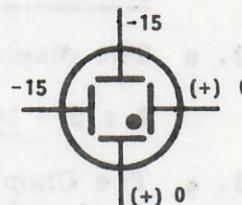
1. d all of the above.

2. a The electron beam is formed by the electron gun.

3. d The equivalent voltages are:



4. b The equivalent voltages are:



5. d change nothing, the beam is already at D.

6. a ramp voltage.

7. a Vertical deflection only results in a vertical trace.

8. b The higher the horizontal sweep frequency, the fewer the cycles that appear on the screen.

9. c Figure 2 represents the horizontal sweep system.

10. b Block A is the horizontal amplifier.

11. b S1 selects internal or external horizontal sweep.

12. c $V_{\text{effective}} = 0.707 \times \text{peak}$
 $= 0.707 \times 10 = \underline{7.07V}$

Period = $6 \text{ cm} \times 50 \mu\text{S} = \underline{300 \mu\text{S} = 0.3 \text{ mS}}$

13. a

$V = (V/\text{cm})(\text{No. of cm})(\times 10)$
 $= (5)(4)(10) = \underline{200V \text{ p-p}}$

2 — UNIT TEST FOR PART G3 (ANSWERS)

14. d The VOLTS/DIV switch controls the display height.
15. d all of the above.
16. b Vertical centering set too high.
17. c Improperly set Trigger control.
18. a Too high a horizontal sweep frequency.
19. d all of the above.
20. b Figure 5 indicates a peak voltage of 15 V and a phase difference of 30 degrees.
21. a The Figure 6 display is caused by a depressed CH 2 INVERT switch.
22. a The display will cover the full 10 divisions horizontally.
 $2 \times 5 = 10 \text{ divisions}$
23. a The Chop mode can cause gaps to appear in the displayed waveform.
24. c The two signals are added algebraically.
25. d all of the above.
26. b VOM ac scales are calibrated in rms volts unless otherwise noted.
27. a sine waves.
VOM ac scales are correct for sine wave input voltages only.
28. c
$$\frac{(\text{VOLTS/DIV})(\text{No. of Vert Div})(\text{Probe Setting})}{2}$$
29. d 20 kHz.
$$f = \frac{1}{T} = \frac{1}{50 \times 10^{-6}}$$

$$= 20,000 \text{ Hz} = 20 \text{ kHz}.$$
30. d all of the above.
31. b (R)(C)

The time constant of an RC circuit is equal to (R)(C).

32. c 63.2 volts.

In one TC a capacitor charges to 63.2% of the applied voltage or 63.2 volts.

33. b 5 TC.

A capacitor is considered to be fully charged after 5 TC.

34. c L/R.

The time constant of an RL circuit is equal to L/R.

35. a 0.5 seconds.

$$T = RC$$

$$= 5 \times 10^3 \times 100 \times 10^{-6}$$

$$= 500 \times 10^{-3} = \underline{0.5 \text{ seconds}}$$

36. c 0.0015 S.

$$T = \frac{L}{R} = \frac{3}{2000} = \underline{0.0015 \text{ S}}$$

37. d all of the above.

38. b inductor.

39. a negative saturation.

40. c negative coercivity, $-H_c$.

41. c One side of the power line is grounded just before entering a building in order to protect against the effects of a lightning strike.

42. a The standard house wiring color code is Black hot; Green ground; White neutral.

43. b The person shown in Figure 8 is receiving a possibly lethal shock.

44. d all of the above.

45. c both (a) and (b).

NAME _____ Marking Key _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST Q3

1. d 10. b 19. d 28. c 37. d

2. a 11. b 20. b 29. d 38. b

3. d 12. c 21. a 30. d 39. a

4. b 13. a 22. a 31. b 40. c

5. d 14. d 23. a 32. c 41. c

6. a 15. d 24. c 33. b 42. a

7. a 16. b 25. d 34. c 43. b

8. b 17. c 26. b 35. a 44. d

9. c 18. a 27. a 36. c 45. c

Unit Test
G4—AC RLC Circuits

Unit Test
G4—RC RLC Circuits

Unit Test

Part G4—AC RLC Circuits

Answer the following multiple choice questions.

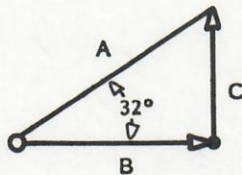


Figure 1 above refers to questions 1 to 5.

- The phasor diagram in Figure 1 represents a series circuit of a (an) _____ and a (an) _____.
 - resistor; inductor.
 - resistor; capacitor.
 - inductor; capacitor.
 - resistor; resistor.
- The phasor diagram in Figure 1 indicates that the resistive voltage drop and the reactive voltage drop are out of phase by:
 - 32° .
 - 58° .
 - 90° .
 - 122° .
- In Figure 1, given that B and C are resistance and reactance, respectively, A is:
 - the applied voltage.
 - theta.
 - the impedance.
 - none of the above.
- If, in Figure 1, B equals 30 and C equal 40, A must equal:
 - 10.
 - 50.
 - 70.
 - 120.
- In the phasor diagram of Figure 1, given that line A is the applied voltage, the current flow (leads; lags) _____ the applied voltage by _____.
 - leads; 90° .
 - lags; 90° .
 - leads; 32° .
 - lags; 32° .
- When two ac voltages are out of phase they must be added using:
 - phasors.
 - vectors.
 - Pythagorean Theorem.
 - any of the above.

Part 2—AC RLC Circuits

Answer the following multiple choice questions.



Figure 1 shows refers to questions 1 to 5.

- The phasor diagram in Figure 1 represents a series circuit of a (an) _____ and a (an) _____.
 a. resistor; inductor.
 b. capacitor; inductor.
 c. resistor; capacitor.
 d. capacitor; resistor.
- The phasor diagram in Figure 1 indicates that the _____ voltage drops and the _____ voltage drop are out of phase by _____.
 a. 33°
 b. 55°
 c. 133°
 d. 155°
- In Figure 1, given that R and X are resistance and reactance, respectively, A is _____.
 a. the applied voltage.
 b. the current.
 c. the impedance.
 d. none of the above.
- In Figure 1, Z equals 50 and C equals 50. A must equal _____.
 a. 10.
 b. 50.
 c. 150.
 d. 170.
- In the phasor diagram of Figure 1, given that I is the current, the voltage drop across the capacitor is _____.
 a. 10°
 b. 50°
 c. 130°
 d. 170°
- When two AC voltages are out of phase they must be added using _____.
 a. phasors.
 b. vectors.
 c. trigonometric functions.
 d. any of the above.

7. In a capacitive circuit, the current:
- and voltage are in phase.
 - leads the voltage.
 - lags the voltage.
 - leads on the first half cycle and lags on the second half cycle.
8. In an inductive circuit, the current:
- and voltage are in phase.
 - leads the voltage.
 - lags the voltage.
 - lags the voltage on the first half cycle and leads on the second half cycle.
9. The equation below that is wrong is:
- $R_T = R_1 + R_2 + R_3$
 - $X_{CT} = X_{C1} + X_{C2} + X_{C3}$
 - $Z = R_1 + X_L$
 - $I = E/Z$
10. If, in a series RC circuit, the value of R is gradually increased, the value of:
- θ decreases.
 - θ increases.
 - θ remains the same.
 - X_C also increases.
11. In a series RLC circuit, given that X_L is 2K and X_C is 500 ohms, the effective reactance is closest to:
- 1500 ohms.
 - $\sqrt{1500}$
 - 2000 ohms.
 - $\sqrt{2000}$

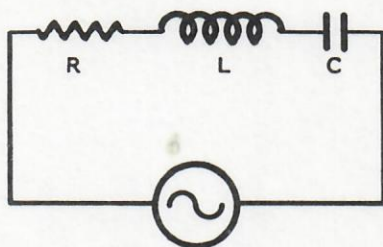


Figure 2 above refers to question 12.

12. For the circuit of Figure 2, given that V_R is 20 volts, V_L is 15 volts and V_C is 12 volts, the source voltage is closest to:
- 47 volts.
 - 23 volts.
 - 20.2 volts.
 - 7 volts.

7. In a capacitive circuit, the current:
 - a. and voltage are in phase.
 - b. leads the voltage.
 - c. lags the voltage.
 - d. leads on the first half cycle and lags on the second half cycle.
8. In an inductive circuit, the current:
 - a. and voltage are in phase.
 - b. leads the voltage.
 - c. lags the voltage.
 - d. lags the voltage on the first half cycle and leads on the second half cycle.
9. The equation below that is wrong is:
 - a. $R_T = R_1 + R_2 + R_3$
 - b. $X_T = X_1 + X_2 + X_3$
 - c. $Z = Z_1 + Z_2 + Z_3$
 - d. $I = I_1 + I_2 + I_3$
10. If in a series RC circuit the value of R is gradually increased, the value of:
 - a. Z decreases.
 - b. I decreases.
 - c. Z increases the same.
 - d. XC also increases.
11. In a series RLC circuit, when XL is 25 and XC is 200 ohms, the effective impedance is closest to:
 - a. 1500 ohms.
 - b. 1100 ohms.
 - c. 1000 ohms.
 - d. 150 ohms.



Figure 1 above refers to question 12.

12. For the circuit of Figure 1, given that V_T is 25 volts, V_R is 15 volts and V_C is 12 volts, the source voltage is closest to:
 - a. 25 volts.
 - b. 22 volts.
 - c. 20.3 volts.
 - d. 7 volts.

13. In a series RC circuit:
- when X_C equals R , θ is always 45° .
 - the current always leads the source voltage.
 - V_{XC} can never exceed the source voltage.
 - all of the above.
14. Inductive reactance varies:
- inversely with frequency.
 - directly with the inductance value.
 - when the series resistance is varied.
 - none of the above.
15. Inductive reactance is defined as opposition to the flow of:
- dc as measured in cemf.
 - ac as measured in cemf.
 - dc as measured in ohms.
 - ac as measured in ohms.
16. A 100 mH coil with a resistance of 1K, when connected to a source of 1.5 kHz, has a reactance of:
- | | |
|----------------|-----------|
| a. 942 ohms. | c. 150 K. |
| b. 1,942 ohms. | d. 942 K. |
17. The reactance of a capacitor varies:
- directly with frequency.
 - directly with capacity.
 - inversely with frequency.
 - by the square of C .
18. The plot of capacitive reactance versus frequency results in a:
- straight line due to their reciprocal relationship.
 - non-linear plot due to their reciprocal relationship.
 - straight line due to their linear relationship.
 - none of the above.

11. In a series RC circuit:

- a. when X_C equals R , ϕ is negative 45° .
- b. the circuit always leads the source voltage.
- c. V_{RC} can never exceed the source voltage.
- d. all of the above.

12. Inductive reactance varies:

- a. inversely with frequency.
- b. directly with the inductance value.
- c. when the source voltage is varied.
- d. none of the above.

13. Inductive reactance is defined as opposition to the flow of:

- a. AC as measured in ohms.
- b. AC as measured in volts.
- c. AC as measured in amperes.
- d. AC as measured in watts.

14. A 100-ohm coil with a resistance of 15, when connected to a source of 1.5 kHz, has a reactance of:

- a. 545 ohms
- b. 1,573 ohms
- c. 150 Ω
- d. 157 Ω

15. The reactance of a capacitor varies:

- a. directly with frequency.
- b. directly with inductance.
- c. inversely with frequency.
- d. by the square of C .

16. The plot of inductive reactance versus frequency results in a:

- a. straight line due to their reciprocal relationship.
- b. curve, but due to their reciprocal relationship.
- c. straight line due to their linear relationship.
- d. none of the above.

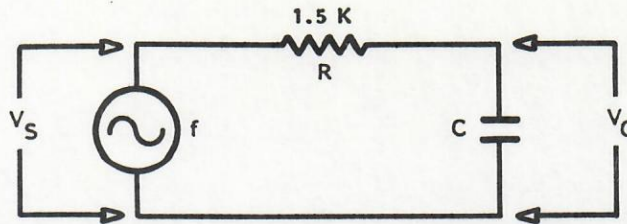


Figure 3 above refers to questions 19 to 23.

19. In the circuit of Figure 3, as f is increased:
 - a. V_O will also increase.
 - b. V_R will decrease.
 - c. V_S will increase.
 - d. V_O will decrease.
20. If, in the circuit of Figure 3, V_R equals 1.5 volts and V_C 2.3 volts, the reactance of C is equal to:
 - a. 2300 ohms.
 - b. 2.3 ohms.
 - c. 1.5 K.
 - d. 2.75 K.
21. If, in Figure 3, the reactance of C is 637 ohms, the circuit impedance is closest to:
 - a. 4622 ohms.
 - b. 2137 ohms.
 - c. 1630 ohms.
 - d. 863 ohms.
22. If, in Figure 3, the reactance of C is 637 ohms and V_S is 10 volts, the voltage drop across R will be closest to:
 - a. 10V.
 - b. 9.2V.
 - c. 3.9V.
 - d. none of the above.
23. If, in the circuit of Figure 3, the voltage drop across R is 15 volts and across C , 20 volts, the source voltage, V_S is closest to:
 - a. 10V.
 - b. 25V.
 - c. 35V.
 - d. 40V.
24. The phase angle in a RC circuit is the difference, in degrees, between the:
 - a. circuit current and the applied voltage.
 - b. voltage drop across the resistor and the voltage drop across the capacitor.
 - c. current through the capacitor and the voltage drop across the capacitor.
 - d. all of the above.
25. A series LC circuit is at resonance when:
 - a. $X_L = L_R$
 - b. $X_C = R$
 - c. $X_C = X_L$
 - d. $X_C = C_R$

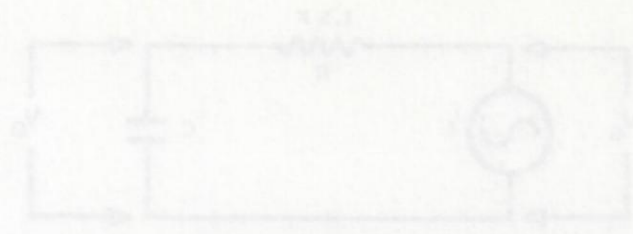


Figure 1 shows values in questions 19 to 25.

19. In the circuit of Figure 1, as f is increased:
 - a. V_C will also increase.
 - b. V_C will decrease.
 - c. V_C will increase.
 - d. V_C will decrease.
20. In the circuit of Figure 1, V_s equals 1.5 volts and V_C 2.1 volts. The resistance of C is equal to:
 - a. 1500 ohms.
 - b. 3.3 ohms.
 - c. 1.5 k.
 - d. 210 k.
21. In Figure 1, the resistance of C is 330 ohms. The current impedance is equal to:
 - a. 450 ohms.
 - b. 330 ohms.
 - c. 1500 ohms.
 - d. 300 ohms.
22. In Figure 1, the resistance of C is 330 ohms and V_s is 15 volts. The voltage drop across R will be closest to:
 - a. 15V.
 - b. 2.5V.
 - c. 3.3V.
 - d. none of the above.
23. In the circuit of Figure 1, the voltage drop across R is 15 volts and across C 20 volts. The source voltage, V_s is equal to:
 - a. 10V.
 - b. 30V.
 - c. 35V.
 - d. 40V.
24. The phase angle in a RC circuit is the difference in degrees between:
 - a. source current and the applied voltage.
 - b. voltage drop across the resistor and the voltage drop across the capacitor.
 - c. current through the capacitor and the voltage drop across the capacitor.
 - d. all of the above.
25. A series RC circuit is at resonance when:
 - a. $X_L = X_C$
 - b. $X_L = Z$
 - c. $X_C = Z$
 - d. $X_L = X_C$

26. In a series resonant circuit:
- a. I is at maximum.
 - b. V_s and I_s are in phase.
 - c. Z is minimum.
 - d. all of the above.
27. The equation to determine resonance is:
- a. $1/2\pi\sqrt{LC}$
 - b. $1/\sqrt{2\pi LC}$
 - c. $1/\sqrt{LC}$
 - d. none of the above.
28. A series resonant circuit consists of a $200\ \mu\text{H}$ inductor and a $0.0025\ \mu\text{F}$ capacitor. The circuit resonant frequency is closest to:
- a. 1.4 MHz.
 - b. 564.3 kHz.
 - c. 225.2 kHz.
 - d. none of the above.
29. In a series resonant circuit, the response curve:
- a. is sharp if the coil resistance is high.
 - b. is sharp if the coil resistance is low.
 - c. is broad if the coil resistance is low.
 - d. shape is independent of the coil resistance.
30. A series RLC circuit is resonant at 1 MHz, has an X_C of 25 K and a resistance of 100 ohms. The circuit quality factor is closest to:
- a. 250 ohms.
 - b. 1,000.
 - c. 250.
 - d. 100.
31. The skin effect in the wire used to wind a coil is greatest when the:
- a. operating frequency is lowest.
 - b. wire diameter is the greatest.
 - c. circuit resistance is the lowest.
 - d. operating frequency is the highest.
32. The bandwidth of a resonant circuit is:
- a. equal to the resonant frequency divided by 2.
 - b. equal to the resonant frequency multiplied by 0.5.
 - c. measured between the half power points of the resonance curve.
 - d. measured between the half voltage points on the resonance curve.

26. In a series resonant circuit:
 - a. V_L and V_C are in phase.
 - b. V_L and V_C are 180° out of phase.
 - c. V_L is leading.
 - d. V_C is leading.
27. The condition for maximum average power transfer is:
 - a. $Z_L = Z_S^*$
 - b. $Z_L = Z_S$
 - c. $Z_L = \sqrt{Z_S}$
 - d. none of the above.
28. A series resonant circuit consists of a 100 Ω resistor and a 0.001 μ F capacitor. The circuit resonance frequency is closest to:
 - a. 1.5 MHz
 - b. 150 kHz
 - c. 150.3 kHz
 - d. none of the above.
29. In a series resonant circuit, the response curve:
 - a. is sharp if the coil resistance is high.
 - b. is sharp if the coil resistance is low.
 - c. is broad if the coil resistance is low.
 - d. sharp is independent of the coil resistance.
30. A series RLC circuit is resonant at 1 MHz. It has an X_L of 25 Ω and a resistance of 10 Ω . The circuit quality factor is closest to:
 - a. 250 ohms
 - b. 1,000
 - c. 250
 - d. 100
31. The skin effect in the wire used to wind a coil is:
 - a. greatest when the operating frequency is lowest.
 - b. least when the operating frequency is the greatest.
 - c. least when the resistance is the lowest.
 - d. greatest when the resistance is the highest.
32. The bandwidth of a resonant circuit is:
 - a. equal to the resonant frequency divided by Q.
 - b. equal to the resonant frequency multiplied by Q.
 - c. measured between the half power points of the resonance curve.
 - d. measured between the half voltage points on the resonance curve.

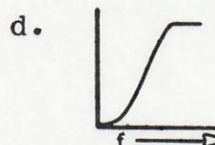
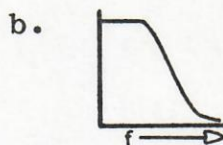
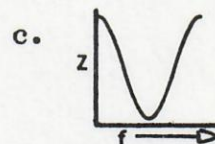
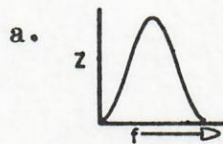
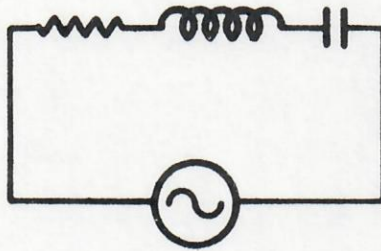
33. The half power points of a series resonant circuit are located at frequencies determined by:

- a. $0.707 \times I_{\text{resonance}}$.
- b. $0.707 \times V_{\text{resonance}}$.
- c. $X_C = R$.
- d. all of the above.

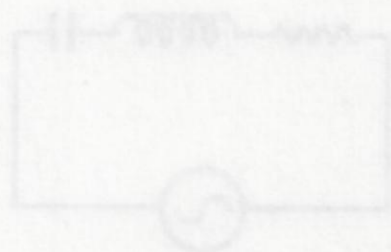
34. The bandwidth of a series resonant circuit is equal to:

- a. f_r / Q .
- b. $f_2 - f_1$.
- c. $(f_r) R / X_L$.
- d. all of the above.

35. The correct plot of impedance versus frequency for the circuit shown below, is:



32. The half-power points of a series resonant circuit are located at frequencies determined by:
- $\omega = \omega_0 \pm \frac{R}{L}$
 - $\omega = \omega_0 \pm \frac{1}{Q}$
 - all of the above.
33. The bandwidth of a series resonant circuit is equal to:
- $\omega_0 (R/L)$
 - ω_0 / Q
 - all of the above.
34. The constant part of impedance versus frequency for the circuit shown below is:



NAME _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G4

- | | | | | |
|----------|-----------|-----------|-----------|-----------|
| 1. _____ | 8. _____ | 15. _____ | 22. _____ | 29. _____ |
| 2. _____ | 9. _____ | 16. _____ | 23. _____ | 30. _____ |
| 3. _____ | 10. _____ | 17. _____ | 24. _____ | 31. _____ |
| 4. _____ | 11. _____ | 18. _____ | 25. _____ | 32. _____ |
| 5. _____ | 12. _____ | 19. _____ | 26. _____ | 33. _____ |
| 6. _____ | 13. _____ | 20. _____ | 27. _____ | 34. _____ |
| 7. _____ | 14. _____ | 21. _____ | 28. _____ | 35. _____ |

ANSWER SHEET—UNIT TEST 64

1.	_____	8.	_____	15.	_____	22.	_____	29.	_____
2.	_____	9.	_____	16.	_____	23.	_____	30.	_____
3.	_____	10.	_____	17.	_____	24.	_____	31.	_____
4.	_____	11.	_____	18.	_____	25.	_____	32.	_____
5.	_____	12.	_____	19.	_____	26.	_____	33.	_____
6.	_____	13.	_____	20.	_____	27.	_____	34.	_____
7.	_____	14.	_____	21.	_____	28.	_____	35.	_____

Unit Test

Part G4—AC RLC Circuits

Instructor's Answer Sheet

1. a The phasor diagram represents a series circuit of a resistor and an inductor.
2. c 90°
3. c The impedance.
4. b 50
$$A = \sqrt{B^2 + C^2} = \sqrt{30^2 + 40^2}$$
$$A = \sqrt{2500} = \underline{50}$$
5. d The current flow lags the applied voltages by 32° .
6. d all of the above.
7. b leads the voltage.
8. c lags the voltage.
9. c $Z = \sqrt{R^2 + X_L^2}$
10. a As R is increased θ decreases.
11. a 1500 ohms
$$\text{Net } X = X_L - X_C \quad 2000 - 500 = \underline{1500 \text{ ohms.}}$$
12. c 20.2 volts
$$V_S = \sqrt{V_{R2}^2 + (V_L - V_C)^2} = \sqrt{20^2 + (15 - 12)^2}$$
$$= \sqrt{400 + 9} = \underline{20.223 \text{ V}}$$
13. d all of the above.
14. b Inductive reactance varies directly with inductance.
15. a X_L is the opposition to the flow of ac, measured in ohms.
16. a 942 ohms
$$X_L = 2\pi fL = (6.28)(1500)(0.1) = \underline{942 \text{ ohms}}$$
17. c X_C varies inversely with frequency.

2 — UNIT TEST FOR PART G4 (ANSWERS)

18. b The plot of X_C versus f is non-linear due to their inverse relationship.

19. d In the circuit of Figure 3, as f is increased, V_o will decrease.

20. a 2.3K

$$X_C = \frac{V_C}{I_C} = \frac{2.3}{\frac{V_R}{R}} = \frac{2.3}{\frac{1.5}{1500}} = \underline{2300 \text{ ohms}}$$

21. c 1630 ohms

$$Z = \sqrt{R^2 + X_C^2} = \sqrt{1500^2 + 637^2}$$

$$Z = \underline{1629.65 \text{ ohms}}$$

22. b 9.2V The circuit Z is 1630 ohms from question 21 above.

$$I = \frac{E}{Z} = \frac{10}{1630} = 0.006A$$

$$V_R = R \cdot I_R = (1500)(0.006) = \underline{9.2V}$$

23. b 25V

$$V_S = \sqrt{V_R^2 + V_C^2} = \sqrt{15^2 + 20^2}$$

$$V_S = \sqrt{225 + 400} = \underline{25 \text{ V}}$$

24. a The phase angle in an RC circuit is the difference, in degrees, between the circuit current and the applied voltage.

25. b An LC circuit is resonant when $X_C = X_L$.

26. a all of the above.

27. a

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

28. c 225.2 kHz

$$\begin{aligned}
 f_r &= \frac{1}{6.28 \sqrt{(1200 \times 10^{-6})(0.0025 \times 10^{-6})}} \\
 &= \frac{1}{6.28 \sqrt{0.5 \times 10^{-12}}} = \frac{10^6}{(6.28)(0.707)} \\
 &= \underline{225.2 \text{ kHz}}
 \end{aligned}$$

29. b The response curve is sharp if the coil resistance is low.30. c At resonance, $X_C = X_L = \underline{25,000 \text{ ohms}}$

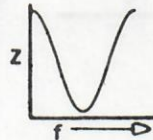
$$Q = \frac{X_L}{R} = \frac{25,000}{100} = \underline{250}$$

31. d Skin effect in the wire used to wind a coil is greatest when the operating frequency is the highest.32. c The bandwidth of a resonant circuit is measured between the half power points on the resonance curve.

33. d all of the above.

34. d all of the above.

35. c



NAME _____ Marking Key _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G4

- | | | | | |
|-------------|--------------|--------------|--------------|--------------|
| 1. <u>a</u> | 8. <u>c</u> | 15. <u>a</u> | 22. <u>b</u> | 29. <u>b</u> |
| 2. <u>c</u> | 9. <u>c</u> | 16. <u>a</u> | 23. <u>b</u> | 30. <u>c</u> |
| 3. <u>c</u> | 10. <u>a</u> | 17. <u>c</u> | 24. <u>a</u> | 31. <u>d</u> |
| 4. <u>b</u> | 11. <u>a</u> | 18. <u>b</u> | 25. <u>b</u> | 32. <u>c</u> |
| 5. <u>d</u> | 12. <u>c</u> | 19. <u>d</u> | 26. <u>a</u> | 33. <u>d</u> |
| 6. <u>d</u> | 13. <u>d</u> | 20. <u>a</u> | 27. <u>a</u> | 34. <u>d</u> |
| 7. <u>b</u> | 14. <u>b</u> | 21. <u>c</u> | 28. <u>c</u> | 35. <u>c</u> |

Unit Test
G5—AC Circuits

Unit Test

02-97 Circuits

Unit Test

Part G5—AC Circuits

Answer the following multiple choice questions.

1. A resonant circuit consists of a parallel R, L and C components. The resistor is removed from the circuit but no other change is made. This causes:
 - a. f_r to increase.
 - b. f_r to decrease.
 - c. Q to increase.
 - d. Z to drop.
2. To increase the bandwidth of a parallel resonant RLC circuit, it is necessary to:
 - a. decrease the coil resistance.
 - b. increase the value of the parallel resistor.
 - c. remove the parallel resistor from the circuit.
 - d. lower the value of the parallel resistor.
3. For a practical LC parallel resonant circuit, the impedance can be approximated from:
 - a. $(Q)(X_L)$.
 - b. $(R)(Q)$.
 - c. $R^2 (X_L - X_C)^2$.
 - d. any of the above.
4. For the parallel RLC circuit, at resonance, the impedance is _____ and the line current is _____.
 - a. high; low.
 - b. high; high.
 - c. low; high.
 - d. low; low.
5. In a parallel resonant circuit _____ is 180° out of phase with _____.
 - a. E_L ; I_L .
 - b. I_L ; I_C .
 - c. I_L ; E_L .
 - d. E_L ; E_C .
6. A parallel LC circuit resonant at 20 kHz has a 50 mH inductor, an impedance of 60 K and a Q of:
 - a. 2.5.
 - b. 9.5.
 - c. 70.
 - d. 80.
7. A parallel LC circuit is resonant at 40 kHz and has a Q of 50. The circuit bandwidth is:
 - a. 158 Hz.
 - b. 900 Hz.
 - c. 68 Hz.
 - d. 800 Hz.

Part 2 - AC Circuits

Answer the following multiple-choice questions.

1. A resonant circuit consists of a parallel R, L and C components. The voltage is removed from the circuit but no other change is made. This causes:
 - a. L to increase.
 - a. L to decrease.
 - a. C to increase.
 - a. C to decrease.
2. To increase the bandwidth of a parallel resonant RLC circuit, it is necessary to:
 - a. decrease the coil resistance.
 - b. increase the value of the parallel resistor.
 - c. remove the parallel resistor from the circuit.
 - d. lower the value of the parallel resistor.
3. For a parallel LC parallel resonant circuit, the impedance can be approximated by:
 - a. $10(X_L - X_C)$
 - b. (R/Q)
 - c. any of the above.
 - d. $10(X_L + X_C)$
4. For the parallel RLC circuit at resonance:

the impedance is _____ and the line current is _____.

 - a. high; low.
 - b. high; high.
 - c. low; high.
 - d. low; low.
5. In a parallel resonant circuit _____ is 180° out of phase with _____.
 - a. V_L ; V_C
 - b. V_L ; V_R
 - c. V_C ; V_R
 - d. V_L ; V_C
6. A parallel LC circuit resonant at 50 kHz has a 20 mH inductor, an impedance of 50 Ω and a Q of:
 - a. 10.
 - b. 50.
 - c. 500.
 - d. 100.
7. A parallel LC circuit is resonant at 40 kHz and has a Q of 50. The circuit bandwidth is:
 - a. 150 Hz.
 - b. 200 Hz.
 - c. 40 Hz.
 - d. 800 Hz.

8. A variable inductor and a parallel capacitor can tune to a low frequency of 600 kHz. To lower the tuning range to 540 kHz it is necessary to:
- reduce the value of L by withdrawing the slug.
 - increase the value of L by withdrawing the slug.
 - increase the value of the parallel capacitor.
 - decrease the value of the parallel capacitor.
9. A parallel LC tuned circuit used to select the desired radio stations, could separate those stations better if the:
- values of L and C were increased.
 - coil used has a low dc resistance and thus a lower Q.
 - values of L and C were decreased.
 - coil used has a low dc resistance and thus a higher Q.
10. An LC tank circuit consists of a 150 μ H inductor and a 300 pF capacitor. The resonant frequency of the circuit is closest to:
- 750.6 mHz.
 - 750.6 kHz.
 - 750.6×10^{13} Hz.
 - 4.7 mHz.
11. The highest frequency of an LC tank circuit can tune in is 1400 kHz. In order to tune to 1600 kHz:
- the parallel capacitance should be reduced.
 - the parallel capacitance should be increased.
 - a capacitor must be placed in parallel with the existing capacitor.
 - an inductor must be placed in series with the existing inductor.
12. A low pass filter will _____ high frequencies and _____ low frequencies.
- pass; pass.
 - block; pass.
 - block; block.
 - pass; block.
13. A high pass filter will _____ high frequencies and _____ low frequencies.
- pass; pass.
 - block; pass.
 - block; block.
 - pass; block.

8. A variable inductor and a parallel capacitor are used to
a low impedance of 500 Ω . To lower the impedance range
to 250 Ω it is necessary to

- a. reduce the value of L by withdrawing the slug.
- b. increase the value of L by withdrawing the slug.
- c. increase the value of the parallel capacitor.
- d. decrease the value of the parallel capacitor.

9. A parallel LC tuned circuit used to select the desired
radio station, could operate between station U
the

- a. values of L and C were increased.
- b. coil used has a low resistance and thus a
lower Q.
- c. values of L and C were decreased.
- d. coil used has a low resistance and thus a
higher Q.

10. An LC tank circuit consists of a 150 μ H inductor and a
300 pF capacitor. The resonant frequency of the circuit
is closest to

- a. 750 kHz
- b. 750.5 kHz
- c. 150.5 kHz
- d. 150 kHz

11. The highest frequency of an LC tank circuit can tune in
is 1500 kHz. In order to tune to 1505 kHz

- a. the parallel capacitance should be reduced.
- b. the parallel capacitance should be increased.
- c. a resistor must be placed in parallel with the
existing capacitor.
- d. an inductor must be placed in series with the
existing inductor.

12. A low pass filter will _____ high frequencies and _____
low frequencies.

- a. pass; pass
- b. block; block
- c. block; pass
- d. pass; block

13. A high pass filter will _____ high frequencies and _____
low frequencies.

- a. pass; pass
- b. block; block
- c. block; pass
- d. pass; block

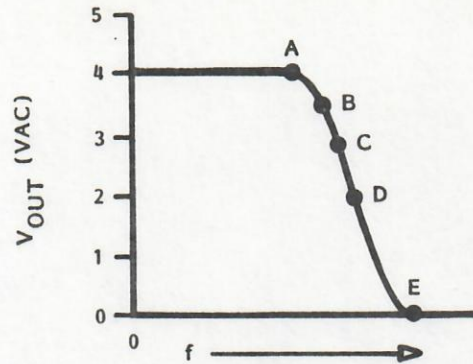


Figure 1 above, refers to questions 14 to 16.

14. Figure 1 is a response curve of a:
- low pass filter.
 - high pass filter.
 - band pass filter.
 - band stop filter.
15. The rejected frequencies indicated by the response curve in Figure 1 are:
- to the left of point A.
 - to the right of point A.
 - to the left of point B.
 - to the right of point C.
16. The half power point in the response curve of Figure 1 is located on the curve at point:
- B.
 - C.
 - D.
 - E.

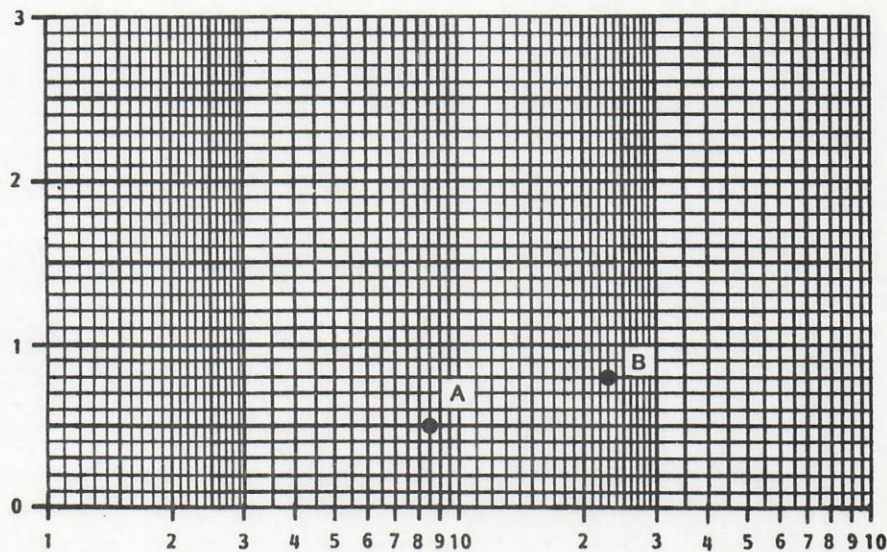


Figure 2 refers to questions 17 and 18.



Figure 1 shows values to questions 14 to 16.

14. Figure 1 is a response curve of a:
- a. low pass filter.
 - b. high pass filter.
 - c. band pass filter.
 - d. band stop filter.
15. The repeated frequencies indicated by the response curve in Figure 1 are:
- a. to the left of point A.
 - b. to the right of point A.
 - c. to the left of point B.
 - d. to the right of point C.
16. The half power point in the response curve of Figure 1 is located on the curve at point:

- a. B.
- b. C.
- c. D.
- d. A.



Figure 2 relates to questions 17 and 18.

17. The graph shown in Figure 2 is:
- rectilinear.
 - log-log 2 cycle.
 - semi-log.
 - linear.
18. In the graph of Figure 2, the X axis is calibrated in frequency and the first cycle is $\text{Hz} \times 10$. The frequency represented by A is _____ Hz and by B is _____ Hz.
- 85; 230.
 - 81; 24.
 - 8.5; 2.3.
 - 850; 230.

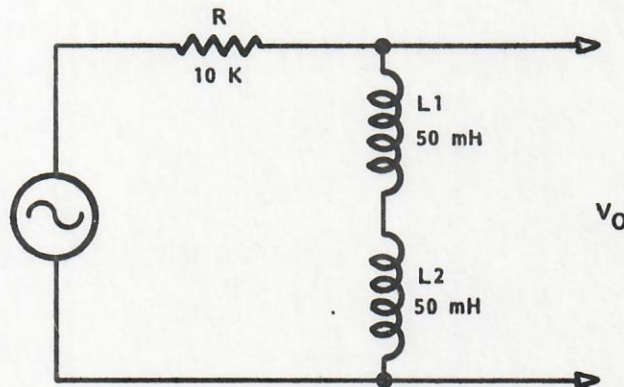


Figure 3 refers to question 19.

19. The circuit shown in Figure 3 is a:
- low pass filter.
 - band pass filter.
 - band stop filter.
 - high pass filter.

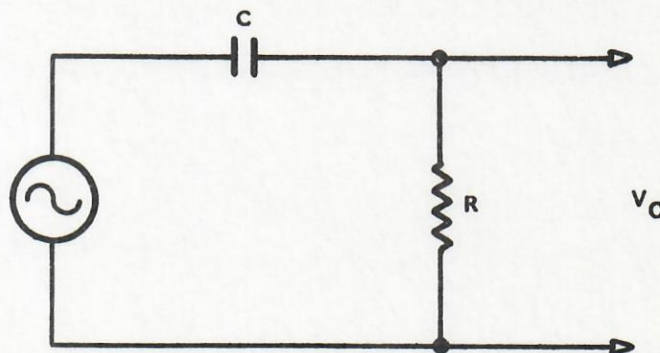


Figure 4 refers to questions 20 to 22.

20. The circuit of Figure 4 is a (an):
- RL high pass filter.
 - RC low pass filter.
 - RC high pass filter.
 - band pass filter.

17. The graph shown in Figure 2 is:

- a. a straight line
- b. a curve
- c. a parabola
- d. a hyperbola

18. In the graph of Figure 2, the X axis is labeled in units of $\frac{1}{f}$ and the Y axis is labeled in units of $\frac{1}{V}$. The relationship represented by A is _____ and by B is _____.

- a. $\frac{1}{V} = 200 \frac{1}{f}$
- b. $\frac{1}{V} = 200 \frac{1}{f}$
- c. $\frac{1}{V} = 200 \frac{1}{f}$
- d. $\frac{1}{V} = 200 \frac{1}{f}$

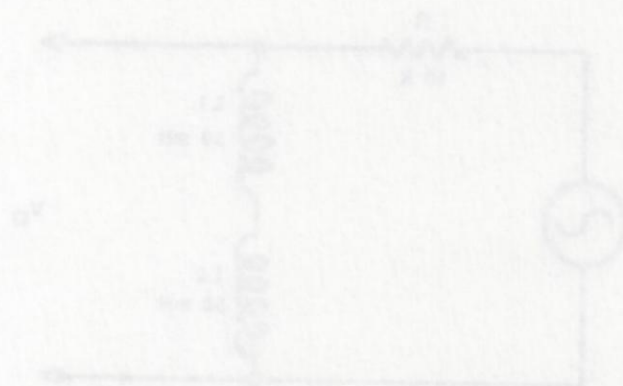


Figure 2 refers to question 17.

19. The circuit shown in Figure 3 is:

- a. low pass filter
- b. high pass filter
- c. band pass filter
- d. band stop filter

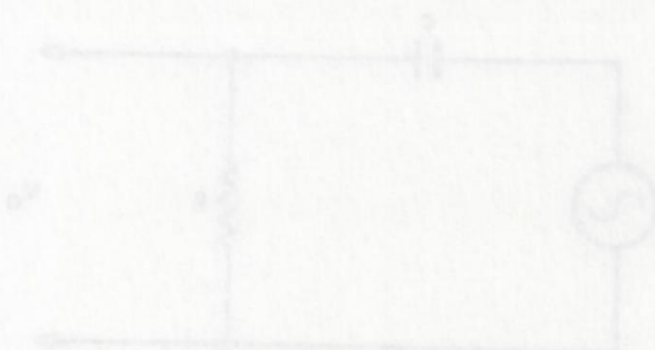


Figure 3 refers to question 19 to 22.

20. The circuit of Figure 3 is a:

- a. low pass filter
- b. high pass filter
- c. band pass filter
- d. band stop filter

21. As the input frequency to the circuit of Figure 4 decreases, X_C _____ and V_o _____.
- a. increases; decreases. c. increases; increases.
b. decreases; increases. d. decreases; decreases.
22. When the input frequency in Figure 4 is at the f_c value:
- a. $X_C = 2R$. c. $2X_C = R/2$.
b. $2X_C = 2R$. d. $V_o = 2.12 \times V_{MAX}$.

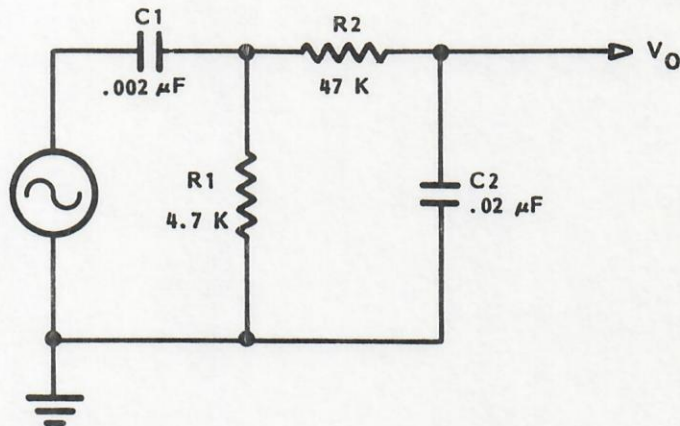


Figure 5 above refers to questions 23 to 25.

23. The circuit of Figure 5 is closest to a:
- a. low pass filter. c. band stop filter.
b. high pass filter. d. band pass filter.
24. In the circuit of Figure 5, a low pass filter is formed by:
- a. C_1 and C_2 . c. R_1 and C_1 .
b. R_1 and R_2 . d. C_2 and R_2 .
25. In the circuit of Figure 5, a high pass filter is formed by:
- a. C_1 and C_2 . c. R_1 and C_1 .
b. R_1 and R_2 . d. C_2 and R_2 .
26. A parallel resonant circuit placed in series between the load and the source is a (an):
- a. band pass filter. c. constant-k filter.
b. band stop filter. d. m-derived filter.

25. As the input frequency to the circuit of Figure 2 decreases, V_o and V_i _____.
- a. increase; decrease.
b. decrease; increase.
c. increase; increase.
d. decrease; decrease.
26. When the input frequency in Figure 2 is at the f_c value:
- a. $V_o = 2V_i$
b. $V_o = V_i$
c. $V_o = 0.5V_i$
d. $V_o = 1.5V_i$

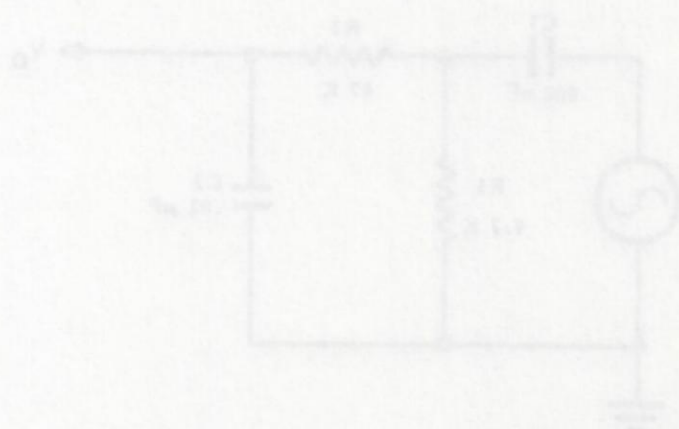


Figure 2 above refers to questions 25 to 30.

27. The circuit of Figure 2 is closest to a:
- a. low pass filter.
b. high pass filter.
c. band stop filter.
d. band pass filter.
28. In the circuit of Figure 2, a low pass filter is formed by:
- a. R_1 and C_1 .
b. R_1 and R_2 .
c. R_2 and C_1 .
d. R_2 and R_1 .
29. In the circuit of Figure 2, a high pass filter is formed by:
- a. C_1 and R_1 .
b. R_1 and R_2 .
c. R_2 and C_1 .
d. C_1 and R_2 .
30. A parallel resonant circuit placed in series between the load and the source is a (n):
- a. band pass filter.
b. band stop filter.
c. constant-K filter.
d. m-derived filter.

27. A parallel resonant circuit placed in parallel with the source will act as a (an):
- a. band pass filter.
 - b. band stop filter.
 - c. constant-k filter.
 - d. m-derived filter.
28. A series resonant circuit wired in series between the source and the load is a (an):
- a. band pass filter.
 - b. band stop filter.
 - c. constant-k filter.
 - d. m-derived filter.
29. A series resonant circuit wired in parallel with the source and load is a (an):
- a. band pass filter.
 - b. band stop filter.
 - c. constant-k filter.
 - d. m-derived filter.

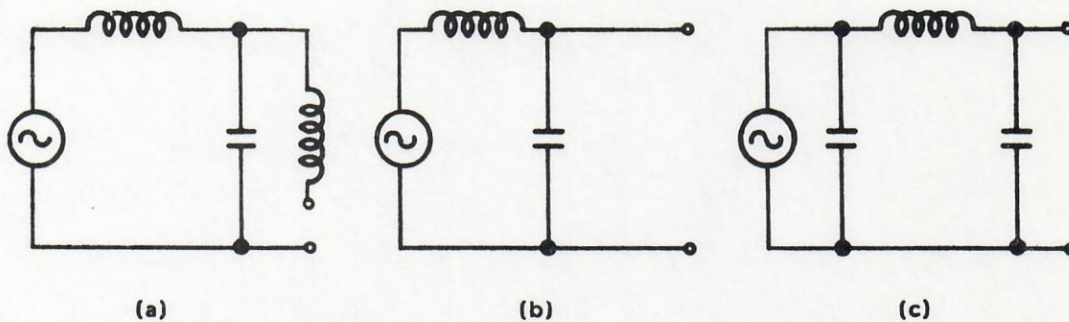


Figure 6 above refers to questions 30 to 32.

30. The filter configuration in Figure 6(a) is a (an):
- a. T network.
 - b. pi network.
 - c. L network.
 - d. series network.
31. The filter configuration in Figure 6(b) is a (an):
- a. T network.
 - b. pi network.
 - c. L network.
 - d. high pass.
32. The filter configuration in Figure 6(c) is a (an):
- a. T network.
 - b. pi network.
 - c. L network.
 - d. m-derived network.
33. A constant-k filter contains only:
- a. R and L components.
 - b. R and C components.
 - c. resonant circuits.
 - d. R, L and C components.

27. A parallel resonant circuit placed in parallel with the source will act as a (an):

- a. band pass filter.
- b. band stop filter.
- c. constant-K filter.
- d. m-derived filter.

28. A series resonant circuit wired in series between the source and the load is a (an):

- a. band pass filter.
- b. band stop filter.
- c. constant-K filter.
- d. m-derived filter.

29. A series resonant circuit wired in parallel with the source and load is a (an):

- a. band pass filter.
- b. band stop filter.
- c. constant-K filter.
- d. m-derived filter.

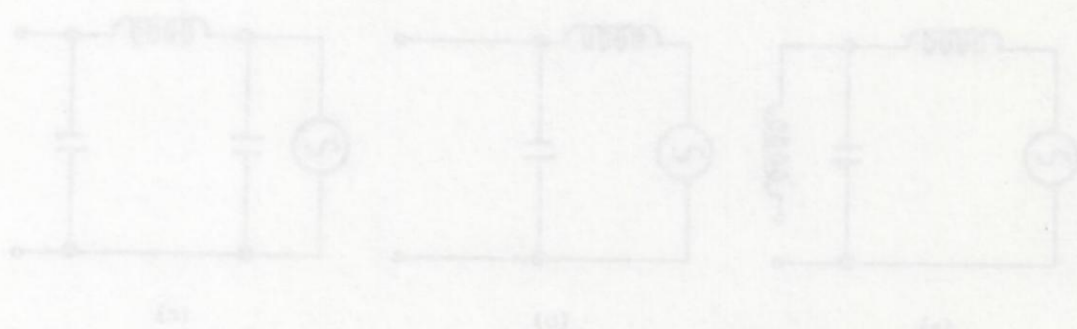


Figure 2 shows filters in questions 30 to 33.

30. The filter configuration in Figure 2(a) is a (an):

- a. T network.
- b. pi network.
- c. L network.
- d. series network.

31. The filter configuration in Figure 2(b) is a (an):

- a. T network.
- b. pi network.
- c. L network.
- d. high pass.

32. The filter configuration in Figure 2(c) is a (an):

- a. T network.
- b. pi network.
- c. L network.
- d. m-derived network.

33. A constant-K filter contains only:

- a. R and L components.
- b. R and C components.
- c. resonant circuits.
- d. R, L and C components.

34. In an m-derived filter:
- there are two critical frequency measurements.
 - the roll-off is steeper than that of an RL filter.
 - the normal value of m is usually close to 0.6.
 - all of the above.

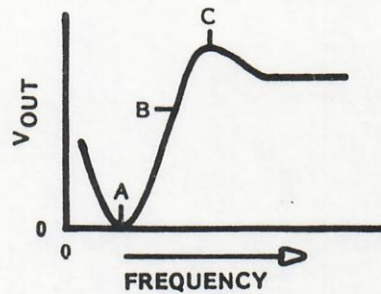


Figure 7 above refers to questions 35 to 37.

35. The response curve shown in Figure 7 is that of a:
- high pass m-derived filter.
 - low pass m-derived filter.
 - high pass RL filter.
 - low pass constant-k filter.
36. Point B on the curve in Figure 7 represents:
- overshoot.
 - f_{∞} .
 - f_c .
 - none of the above.
37. Point A on the curve of Figure 7 represents:
- f_{∞} .
 - the infinite attenuation frequency.
 - both a and b.
 - neither a nor b.
38. Point C on the curve in Figure 7 represents:
- overshoot.
 - f_{∞} .
 - f_c .
 - the infinite attenuation frequency.

34. In an m-derived filter:

- there are two cutoff frequencies.
- the roll-off is steeper than that of an RL filter.
- the image impedance is usually close to 50 Ω .
- all of the above.



Figure 1 shows a filter response in questions 35 to 37.

35. The response curve shown in Figure 1 is that of a:

- high-pass m-derived filter.
- low-pass m-derived filter.
- high-pass RL filter.
- low-pass constant-k filter.

36. Point B on the curve in Figure 1 represents:

- passband.
- stopband.
- none of the above.
- all of the above.

37. Point A on the curve in Figure 1 represents:

- 1 dB .
- the infinite attenuation frequency.
- both A and B.
- neither A nor B.

38. Point C on the curve in Figure 1 represents:

- passband.
- 1 dB .
- 2 dB .
- the infinite attenuation frequency.

39. Two inductors, each rated at 250 mH, are wired in series aiding and placed at right angles (90°) to each other. The total inductance can be determined from:
- $L_1 + L_2$ multiplied by a k of .90 or 450 mH.
 - $L_1 + L_2 + M$ where M equals 90 or 590 mH.
 - $L_1 + L_2$ or 500 mH.
 - none of the above.
40. In order to get the highest mutual inductance between two inductors they must be wired in series _____ and placed physically _____.
- aiding; in parallel.
 - aiding; at right angles.
 - opposing; in parallel.
 - opposing; at right angles.
41. Power in an ac circuits is the same as power in a dc circuit when the ac load is:
- inductive.
 - capacitive.
 - resistive.
 - all of the above.
42. When in an ac circuit, a capacitor:
- stores energy.
 - returns energy to the circuit.
 - consumes no power.
 - all of the above.
43. With an ac resistive-reactive load, the power that has to be paid for is:
- only that power dissipated by the resistance.
 - only that power dissipated by the reactance.
 - the apparent power.
 - the true power.

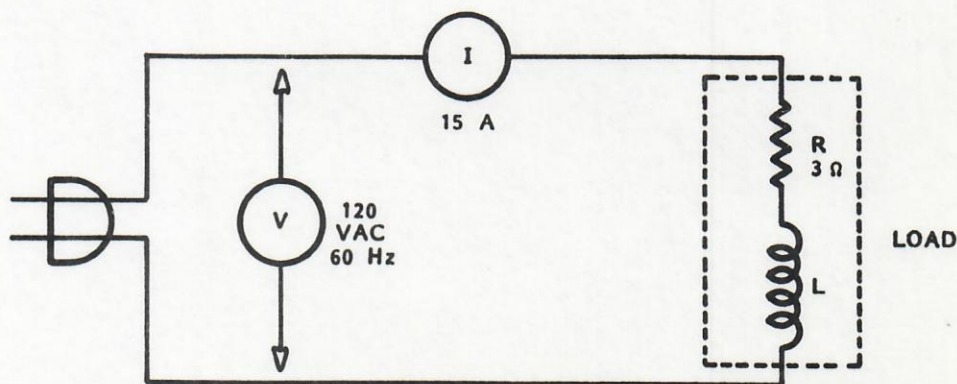


Figure 8 above refers to questions 44 to 46.

39. Two inductors, each rated at 250 mH, are wound in series and placed at right angles (90°) to each other. The total inductance can be determined from:

- a. $L_1 + L_2$ multiplied by a factor of 2 on 250 mH.
- b. $L_1 + L_2 = 500$ mH where 500 equals 250 or 250 mH.
- c. $L_1 + L_2$ or 500 mH.
- d. none of the above.

40. In order to get the highest mutual inductance between two inductors they must be wired in series and placed physically _____

- a. adding in parallel.
- b. adding at right angles.
- c. opposing in parallel.
- d. opposing at right angles.

41. Power in an AC circuit is the same as power in a DC circuit when the AC has an _____

- a. inductive.
- b. capacitive.
- c. resistive.
- d. all of the above.

42. When in an AC circuit, a capacitor _____

- a. stores energy.
- b. returns energy to the circuit.
- c. consumes no power.
- d. all of the above.

43. With an AC resistive load, the power that has to be paid for is _____

- a. only that power dissipated by the resistance.
- b. only that power dissipated by the resistance.
- c. the apparent power.
- d. the true power.

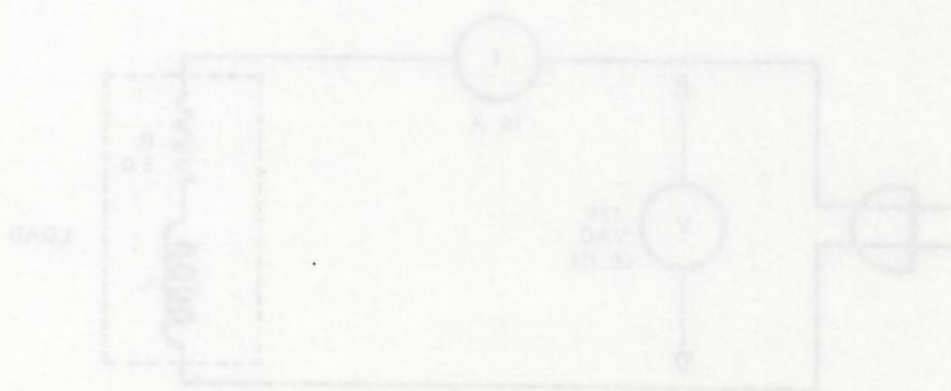


Figure 4 above refers to questions 44 to 46.

44. The apparent power dissipated by the circuit in Figure 8 is:
- a. 1800 watts. c. 675 watts.
b. 900 watts. d. none of the above.
45. The true power dissipated by the circuit in Figure 8 is:
- a. 1800 watts. c. 675 watts.
b. 900 watts. d. none of the above.
46. The power factor for the circuit of Figure 8 is:
- a. 0.125. c. 0.75.
b. 0.375. d. none of the above.
47. The correct formula used to calculate the power factor, PF, is:
- a. $PF = P_T / P_{APP}$. c. $PF = \cos \theta$.
b. $PF = R/Z$. d. all of the above.

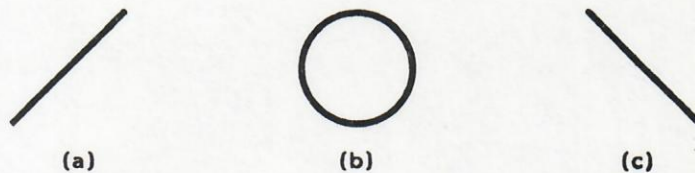


Figure 9 above refers to question 48.

48. The Lissajous patterns shown above in Figure 9(a), (b) and (c) represent:
- a. (a) = 0° ; (b) = 45° ; (c) = 180° .
b. (a) = 180° ; (b) = 45° ; (c) = 0° .
c. (a) = 0° ; (b) = 90° ; (c) = 180° .
d. none of the above.



Figure 10 above refers to questions 49 and 50.

42. The apparent power dissipated by the circuit in Figure 3 is:

- a. 1000 watts.
- b. 500 watts.
- c. 250 watts.
- d. none of the above.

43. The true power dissipated by the circuit in Figure 3 is:

- a. 1000 watts.
- b. 500 watts.
- c. 250 watts.
- d. none of the above.

44. The power factor for the circuit of Figure 3 is:

- a. 0.167.
- b. 0.333.
- c. 0.5.
- d. none of the above.

45. The correct formula used to calculate the power factor is:

- a. $PF = P/VA$
- b. $PF = R/Z$
- c. $PF = \cos \theta$
- d. all of the above.



Figure 3 above refers to question 42.

46. The following patterns show angles in Figure 3(a), (b) and (c) respectively:

- a. (a) = 45° ; (b) = 45° ; (c) = 135°
- b. (a) = 135° ; (b) = 45° ; (c) = 90°
- c. (a) = 90° ; (b) = 45° ; (c) = 135°
- d. none of the above.



Figure 4 above refers to questions 48 and 49.

UNIT TEST FOR PART G5-10

49. Given a horizontal input frequency of 75 Hz to the X channel of the scope, the Y channel frequency indicated by the Lissajous pattern in Figure 19, is:
- | | |
|------------|-------------|
| a. 125 Hz. | c. 375 Hz. |
| b. 225 Hz. | d. 1125 Hz. |
50. Given a Y input of 300 Hz, the X frequency input for the display shown in Figure 10 must be:
- | | |
|------------|-------------|
| a. 125 Hz. | c. 900 Hz. |
| b. 180 Hz. | d. 1500 Hz. |

28. Given a fundamental input frequency of 15 Hz to the X channel of the scope, the Y channel frequency indicated by the Lissajous pattern in Figure 12, was:

- a. 150 Hz.
- b. 375 Hz.
- c. 1125 Hz.
- d. 575 Hz.

29. Given a Y input of 200 Hz, the X frequency input for the display shown in Figure 12 was:

- a. 150 Hz.
- b. 1500 Hz.
- c. 300 Hz.
- d. 1500 Hz.

NAME _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G5

1. _____	11. _____	21. _____	31. _____	41. _____
2. _____	12. _____	22. _____	32. _____	42. _____
3. _____	13. _____	23. _____	33. _____	43. _____
4. _____	14. _____	24. _____	34. _____	44. _____
5. _____	15. _____	25. _____	35. _____	45. _____
6. _____	16. _____	26. _____	36. _____	46. _____
7. _____	17. _____	27. _____	37. _____	47. _____
8. _____	18. _____	28. _____	38. _____	48. _____
9. _____	19. _____	29. _____	39. _____	49. _____
10. _____	20. _____	30. _____	40. _____	50. _____

NAME _____

CLASS _____

DATE _____

REVERSE SHEET—UNIT TEST #2

1	_____	11	_____	21	_____	31	_____
2	_____	12	_____	22	_____	32	_____
3	_____	13	_____	23	_____	33	_____
4	_____	14	_____	24	_____	34	_____
5	_____	15	_____	25	_____	35	_____
6	_____	16	_____	26	_____	36	_____
7	_____	17	_____	27	_____	37	_____
8	_____	18	_____	28	_____	38	_____
9	_____	19	_____	29	_____	39	_____
10	_____	20	_____	30	_____	40	_____

Unit Test

Part G5—AC Circuits

Instructor's Answer Sheet

1. c When the resistance is removed from the parallel RLC circuit, the Q increases because, for a parallel circuit, $Q = R/X_L$.
2. d To increase the bandwidth of a parallel RLC circuit, lower the value of R because $Q = R/X_L$ and $BW = f_r/Q$.
3. a In a practical LC parallel resonant circuit, the impedance can be approximated from $Z = (Q)X_L$.
4. a For a parallel RLC circuit, at resonance, the impedance is high and the line current is low.
5. b In a parallel resonant circuit, I_L is 180° out of phase with I_C .

6. b 9.5

$$Q = \frac{Z}{X_L} = \frac{Z}{2\pi fL} = \frac{60,000}{(6.28)(20 \times 10^3)(50 \times 10^{-3})}$$

$$Q = \frac{60,000}{6,280} = \underline{9.55}$$

7. d 800 Hz

$$BW = \frac{f_r}{Q} = \frac{40,000}{50} = \underline{800 \text{ Hz}}$$

8. c A variable inductor and a parallel capacitor can tune to a low frequency of 600 kHz. To lower the tuning range to 540 kHz, it is necessary to increase the value of the parallel capacitor.
9. d A parallel LC tuned circuit used to select the desired radio station could separate those stations better if the coil used has a low dc resistance and thus a higher Q.

2—UNIT TEST FOR PART G5 (ANSWERS)

10. b 750.6 kHz

$$f_r = \frac{1}{6.28\sqrt{LC}} = \frac{1}{6.28\sqrt{150 \times 10^{-6} \times 300 \times 10^{-12}}}$$

$$= \frac{1}{6.28\sqrt{45000 \times 10^{-18}}} = \frac{10^9}{1332.2} = \underline{750.6 \text{ kHz}}$$

11. a The highest frequency an LC tank circuit can tune in is 1400 kHz. In order to tune to 1600 kHz, the parallel capacitance should be reduced.
12. b A low pass filter will block high frequencies and pass low frequencies.
13. d A high pass filter will pass high frequencies and block low frequencies.
14. a Figure 1 is the response curve of a low pass filter.
15. d The rejected frequencies indicated by the response curve in Figure 1 are to the right of point C.
16. c The half power point in the response curve of Figure 1 is located on the curve at point C.
17. c The graph shown in Figure 2 is semi-log.
18. a In the graph of Figure 2, the frequency represented by A is 85 Hz and by B is 230 Hz.
19. d The circuit shown in Figure 3 is a high pass filter.
20. c The circuit of Figure 4 is an RC high pass filter.
21. a As the input frequency decreases, X_C increases and V_o decreases.
22. b When the input frequency in Figure 4 is at the f_c value, $2X_C = 2R$ or $X_C = R.$
23. d The circuit of Figure 5 is closest to a band pass filter.
24. d In the circuit of Figure 5, a low pass filter is formed by C2 and R2.
25. c In the circuit of Figure 5, a high pass filter is formed by R1 and C1.
26. b A parallel resonant circuit placed in series between the load and the source is a band stop filter.

UNIT TEST FOR PART G5 (ANSWERS) — 3

27. a A parallel resonant circuit placed in parallel with the source will act as a band pass filter.
28. a A series resonant circuit wired in series between the source and the load is a band pass filter.
29. b A series resonant circuit wired in parallel with the source and load is a band stop filter.
30. a The filter configuration in Figure 6(a) is a T network.
31. c The filter configuration in Figure 6(b) is an L network.
32. b The filter configuration in Figure 6(c) is a pi network.
33. d A constant-k filter contains only R, L and C components.
34. d all of the above.
35. a The response curve shown in Figure 7 is that of a high pass m-derived filter.
36. c Point B on the curve of Figure 7 represents f_c .
37. c Point A on the curve in Figure 7 represents f_∞ also called the infinite attenuation frequency.
38. a Point C on the curve in Figure 7 represents overshoot.
39. c 500 mH.
$$L_T = L_1 + L_2 = 250 + 250 \quad L_T = \underline{500 \text{ mH}}$$
40. a In order to get the highest mutual inductance between two inductors they must be wired in series aiding and placed physically in parallel.
41. c Power in an ac circuit is the same as power in a dc circuit when the ac load is resistive.
42. d all of the above.
43. c With an ac resistive-reactive load, the power that has to be paid for is the apparent power.

4 — UNIT TEST FOR PART G5 (ANSWERS)

44. a 1800 watts

$$\begin{aligned} P_{\text{apparent}} &= E_{\text{rms}} I_{\text{rms}} \\ P_{\text{apparent}} &= 120 \times 15 = \underline{1800 \text{ watts}} \end{aligned}$$

45. c 675 watts

$$\begin{aligned} P_{\text{true}} &= I^2 R \\ P_{\text{true}} &= 15^2 (3) = \underline{675 \text{ watts}} \end{aligned}$$

46. b 0.375

$$\begin{aligned} PF &= P_T / P_{\text{app}} \\ &= 675 / 1800 = \underline{0.375} \end{aligned}$$

47. d all of the above.

48. c (a) 0° ; (b) 90° ; (c) 180°

49. a 125 Hz

$$\begin{aligned} \frac{f_v}{f_h} &= \frac{V_{TP}}{H_{TP}} & \frac{f_v}{75} &= \frac{5}{3} \end{aligned}$$

$$3f_v = 375$$

$$f_v = \underline{125 \text{ Hz}}$$

50. b 180 Hz

$$\begin{aligned} \frac{f_v}{f_h} &= \frac{V_{TP}}{H_{TP}} & \frac{300}{f_h} &= \frac{5}{3} \end{aligned}$$

$$5f_h = 900$$

$$f_h = \underline{180 \text{ Hz}}$$

NAME _____ Marking Key _____ CLASS _____ DATE _____

ANSWER SHEET—UNIT TEST G5

- | | | | | |
|--------------|--------------|--------------|--------------|--------------|
| 1. <u>c</u> | 11. <u>a</u> | 21. <u>a</u> | 31. <u>c</u> | 41. <u>c</u> |
| 2. <u>d</u> | 12. <u>b</u> | 22. <u>b</u> | 32. <u>b</u> | 42. <u>d</u> |
| 3. <u>a</u> | 13. <u>d</u> | 23. <u>d</u> | 33. <u>d</u> | 43. <u>c</u> |
| 4. <u>a</u> | 14. <u>a</u> | 24. <u>d</u> | 34. <u>d</u> | 44. <u>a</u> |
| 5. <u>b</u> | 15. <u>d</u> | 25. <u>c</u> | 35. <u>a</u> | 45. <u>c</u> |
| 6. <u>b</u> | 16. <u>c</u> | 26. <u>b</u> | 36. <u>c</u> | 46. <u>b</u> |
| 7. <u>d</u> | 17. <u>c</u> | 27. <u>a</u> | 37. <u>c</u> | 47. <u>d</u> |
| 8. <u>c</u> | 18. <u>a</u> | 28. <u>a</u> | 38. <u>a</u> | 48. <u>a</u> |
| 9. <u>d</u> | 19. <u>d</u> | 29. <u>b</u> | 39. <u>c</u> | 49. <u>a</u> |
| 10. <u>b</u> | 20. <u>c</u> | 30. <u>a</u> | 40. <u>a</u> | 50. <u>b</u> |

GENERAL INQUIRY - UNIT TEST 62

1. c	11. a	21. a	31. c	41. c
2. d	12. b	22. b	32. b	42. d
3. a	13. b	23. c	33. b	43. c
4. a	14. c	24. b	34. b	44. a
5. b	15. b	25. c	35. a	45. c
6. b	16. c	26. b	36. a	46. b
7. d	17. c	27. c	37. c	47. d
8. c	18. a	28. a	38. a	48. a
9. d	19. c	29. b	39. c	49. a
10. b	20. c	30. a	40. a	50. b





Ed-Lab
Instructor's Manual
H1-DIODES and POWER
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Name _____

Class _____

School _____

Ed-Lab
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PART H1

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Ed-Lab Instructor's Manual CLOCK and POWER SUPPLIES PART III

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Part H1 - Diodes and Power Supplies Answer Manual

Information Sheet No. 1 - Solid State PN Junctions

Assignment

- | | | |
|------|-------|-------|
| 1. c | 9. a | 17. b |
| 2. b | 10. b | 18. c |
| 3. a | 11. d | 19. d |
| 4. a | 12. a | 20. b |
| 5. d | 13. d | 21. d |
| 6. b | 14. d | 22. c |
| 7. d | 15. a | 23. c |
| 8. a | 16. a | 24. b |

$$23. \quad r_b = \frac{V - V_D}{I_D} = \frac{1 - 0.7}{0.25} = \underline{1.2\Omega}$$

$$24. \quad r_j = 25/I_F = (25)/0.75 = \underline{33.33\Omega}$$

Information Sheet No. 2 - Rectifier Circuits

Assignment

- | | |
|------|--|
| 1. c | |
| 2. a | |
| 3. b | $V_{dc \text{ av}} = (v_{rms})(0.45) = (30)(0.45) = \underline{13.5V}$
$f \text{ ripple} = f \text{ line} = \underline{30 \text{ Hz}}$ |
| 4. a | $PIV(Hw) = (v_{rms})(1.414) = (45)(1.414) = \underline{63.63 \text{ V}}$ |
| 5. a | $V_{dc(FW)} = (v_{sec}/2)(0.9) = (30/2)(0.9) = \underline{13.5V}$
$f \text{ ripple(FW)} = (2)f \text{ line} = (2)(60) = \underline{120 \text{ Hz}}$ |
| 6. b | |
| 7. d | $PIV(BR) = (v_{sec \text{ rms}})(1.414) = (100)(1.414) = \underline{141.4 \text{ V}}$ |
| 8. d | $V_{dc} = (v_{sec})(0.9) = (100)(0.9) = \underline{90V}$
$f \text{ ripple(BR)} = (2)(f \text{ line}) = (2)(400) = \underline{800 \text{ Hz}}$ |

Part III - Diodes and Power Supplies Answer Manual

Information Sheet No. 1 - Solid State PW Functions

Assignment			
1	c	2	a
2	b	3	b
3	a	4	b
4	a	5	b
5	b	6	b
6	b	7	b
7	b	8	a
8	a	9	a
9	a	10	a
10	a	11	b
11	b	12	b
12	b	13	b
13	b	14	b
14	b	15	a
15	a	16	a
16	a	17	b
17	b	18	c
18	c	19	b
19	b	20	b
20	b	21	b
21	b	22	c
22	c	23	c
23	c	24	b
24	b	25	b

$$25. \quad V = \frac{V - V_D + 1 - 0.7}{0.25} = 1.30$$

$$26. \quad p = 25W = (20V)(1.25A) = 25.0W$$

Information Sheet No. 2 - Rectifier Circuits

Assignment			
1	c	2	a
2	b	3	b
3	b	4	a
4	a	5	a
5	a	6	b
6	b	7	b
7	b	8	a
8	a	9	a
9	a	10	a
10	a	11	b
11	b	12	b
12	b	13	b
13	b	14	b
14	b	15	a
15	a	16	a
16	a	17	b
17	b	18	c
18	c	19	b
19	b	20	b
20	b	21	b
21	b	22	c
22	c	23	c
23	c	24	b
24	b	25	b

Information Sheet No. 3 - Power Supply Filter Circuits

Assignment

1. c $\text{Ripple} = [(v_{ac})/(V_{dc})]100\% = [(0.1)/(27)]100 = \underline{0.37\%}$
2. b
3. d
4. b
5. a $R_s = V_p/I_s = (117)(1.414)/12 = \underline{13.78\Omega}$
 $WRS = (v)(1.414)(12) = (117)(1.414)(12) = \underline{1985.25 \text{ W}}$
6. d
7. a
8. b

Information Sheet No. 4 - Voltage Multiplier Circuits

Assignment

1. d
2. b
3. a
4. d $V_{dc \text{ NL}} = (v_{ac})(1.414)(2) = (117)(1.414)(2) = \underline{330.876V}$
 $f_{\text{ripple(FW)}} = 2 f_{\text{line}} = (2)(60) = \underline{120 \text{ Hz}}$
5. a $V_{dc \text{ NL}} = (v_{ac})(1.414)(4) = (36)(1.414)(4) = \underline{203.62V}$
 $f_{\text{ripple(HW)}} = f_{\text{line}} = \underline{60 \text{ Hz}}$

Information Sheet No. 5 - Diode Testing and Troubleshooting

Assignment

- | | | |
|------|------|-------|
| 1. c | 5. d | 9. d |
| 2. b | 6. c | 10. a |
| 3. a | 7. c | 11. b |
| 4. a | 8. b | |

Information Sheet No. 3 - Power Supply Filter Circuits

Assignment	
1.	c
2.	b
3.	d
4.	c
5.	a
6.	d
7.	a
8.	b

$R_p = V_p / I_p = (11.7V) / (414mA) = 28.25\Omega$
 $W_{ac} = (I_{rms})^2 R_p = (1.70A)^2 (28.25\Omega) = 80.1W$
 $I_{rms} = I_p / \sqrt{2} = 414mA / \sqrt{2} = 292mA$

Information Sheet No. 4 - Voltage Divider Circuits

Assignment	
1.	d
2.	b
3.	a
4.	d
5.	a

$V_{ac} = I_p \times R_p = (1.70A) (414\Omega) = 703.8V$
 $I_{rms} = I_p / \sqrt{2} = 414mA / \sqrt{2} = 292mA$
 $W_{ac} = (I_{rms})^2 R_p = (0.292A)^2 (414\Omega) = 35.1W$
 $V_{ac} = I_p \times R_p = (1.70A) (414\Omega) = 703.8V$
 $I_{rms} = I_p / \sqrt{2} = 414mA / \sqrt{2} = 292mA$

Information Sheet No. 5 - Bridge Testing and Troubleshooting

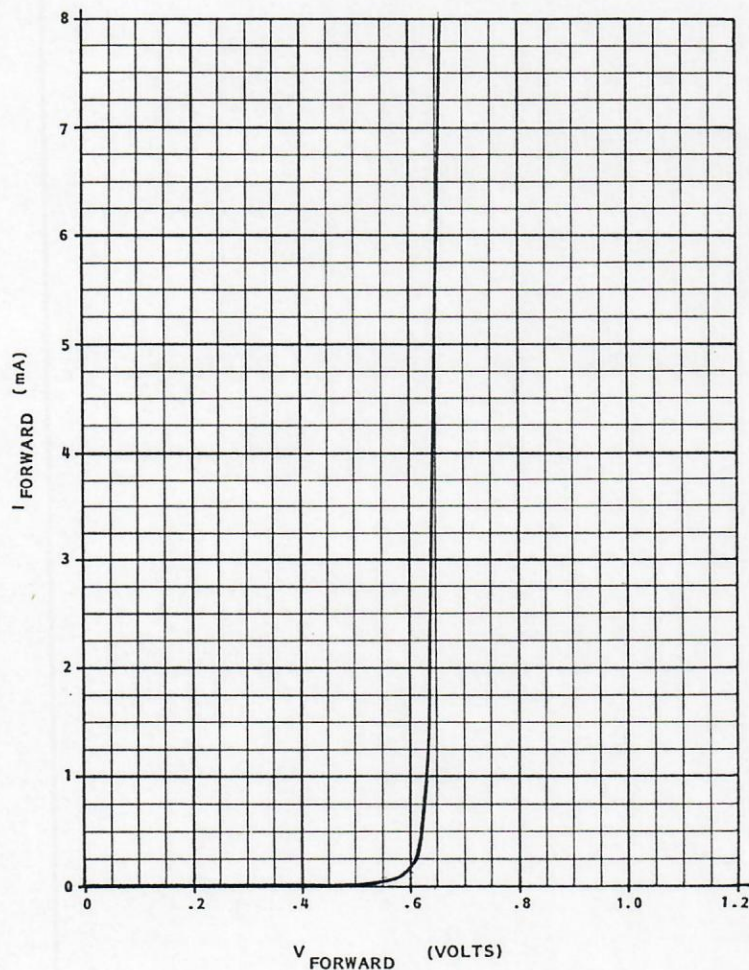
Assignment	
1.	c
2.	b
3.	a
4.	a

$R_p = V_p / I_p = (11.7V) / (414mA) = 28.25\Omega$
 $W_{ac} = (I_{rms})^2 R_p = (1.70A)^2 (28.25\Omega) = 80.1W$
 $I_{rms} = I_p / \sqrt{2} = 414mA / \sqrt{2} = 292mA$

Experiment No. 1 - Diode Characteristic Curve Plot**Procedure**

2.

V _F	I _F	V _F	I _F
0	0	0.55*	30 μ A
0.1	0	0.6*	50 μ A
0.2	0	0.65	6 mA
0.3*	0.5 μ A	0.7	16 mA
0.4*	4 μ A	0.75	48 mA
0.5*	15 μ A	0.8	80 mA

Table 1 - Silicon diode forward voltage *versus* current.3. Silicon Diode Leakage Current, $I_L = 0 \mu A$ 4. $V_{B Si} = 0.7V$ **Figure 2 - Silicon diode forward voltage-current characteristics.**

Experiment No. 1 - Diode Characteristic Curve Plot

Procedure

VR	IR	VR	IR
0	0	0.01	100 μ A
0.1	0	0.05	200 μ A
0.2	0	0.10	300 μ A
0.3	0.01 A	0.20	400 μ A
0.4	0.02 A	0.30	500 μ A
0.5	0.03 A	0.40	600 μ A

Table I - Silicon diode forward voltage versus current.

3. Silicon Diode Leakage Current, IR = 0.01 A

4. VR = 0.7 V

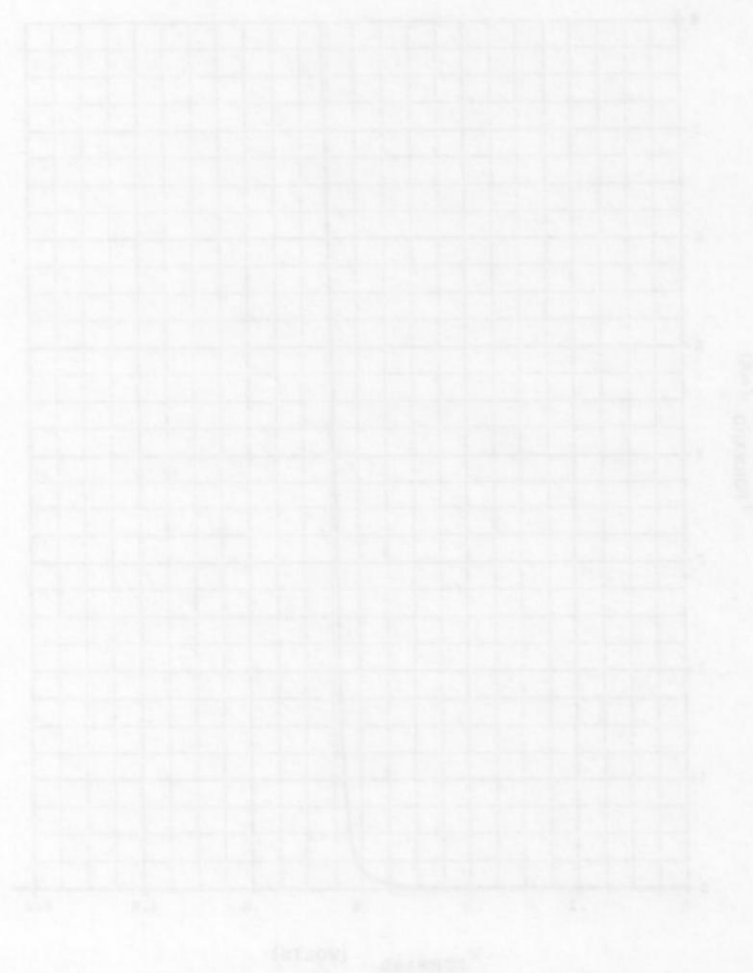


Figure 2 - Silicon diode forward voltage-current characteristic.

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6.

V _F	I _F	V _F	I _F
0	0	0.3	1.6 mA
0.1*	7 μ A	0.35	3.0 mA
0.2*	50 μ A	0.4	5.4 mA
0.25*	0.7 mA	0.45	8.4 mA

TABLE 2- Germanium diode V_F versus I_F.

7.

Germanium Diode Leakage Current, $I_L = 1 \mu A$

8.

$V_{B\text{ Ge}} = 0.3V$

Yes, the forward diode voltages drops for Si and Ge are very close.

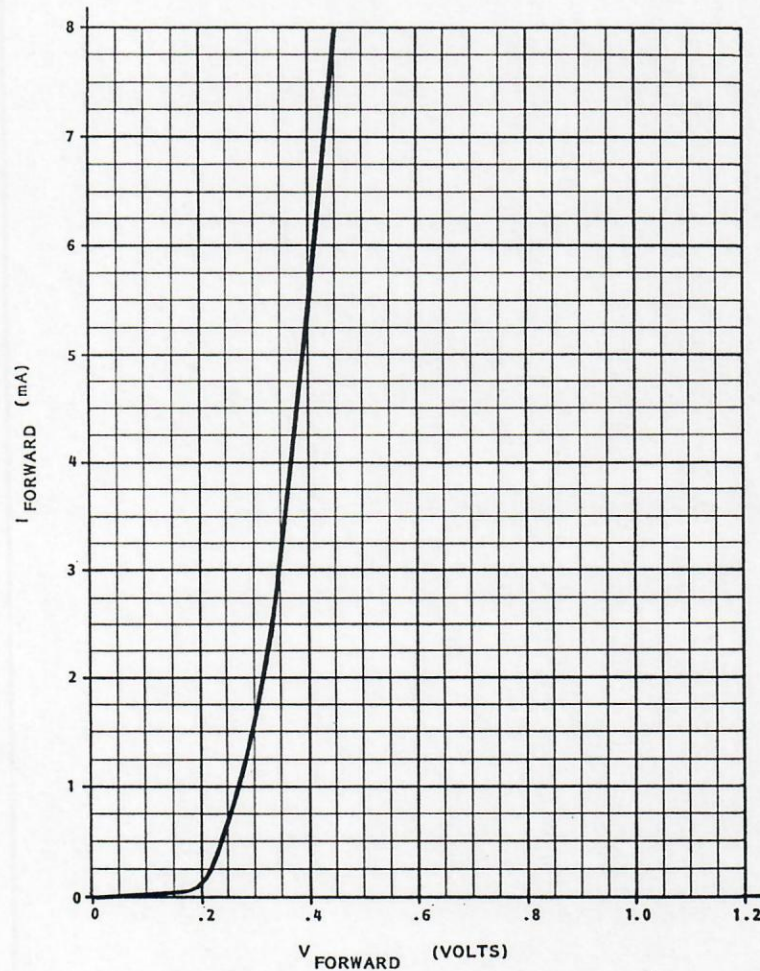


Figure 4 - Germanium diode forward voltage-current characteristics.

V_{CE}	I_C	V_{CE}	I_C
0	0	0.3	0.3
0.1	0.1	0.5	0.5
0.2	0.2	0.7	0.7
0.3	0.3	0.9	0.9

TABLE 2 - Characteristics of PNP in series

Characteristics of PNP in series, $R = 1.5 \Omega$

$V_{BE} = 0.7V$

For the PNP in series, the voltage drop is 0.7V and 0.7V are very close

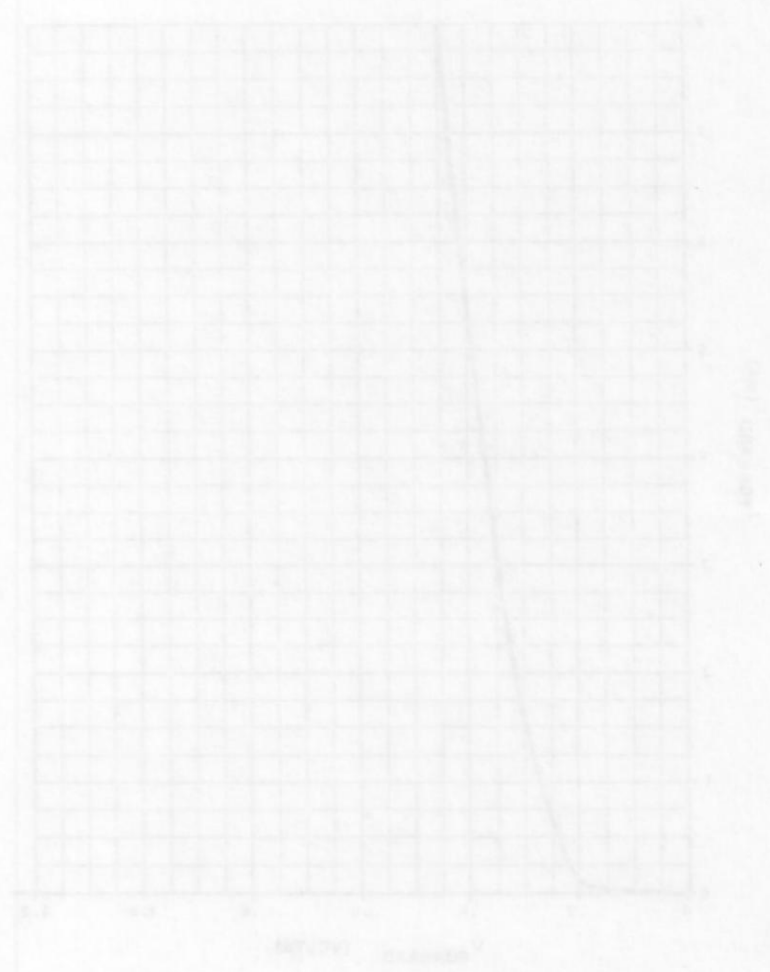


Figure 4 - Characteristics of PNP in series

9. V_F at 30 mA = 0.76 V_F at 50 mA = 0.8

10. $R_{\text{bulk}} = \frac{\Delta V_F}{\Delta I_F} = \frac{\Delta V_F}{50 \text{ mA} - 30 \text{ mA}} \times 10^3$

$$R_{\text{bulk}} = \frac{(0.8) - (0.76)}{0.02} = \frac{(0.04)}{0.02} = \underline{2} \Omega$$

11. V_F at 4 mA = 0.372 V_F at 7 mA = 0.426

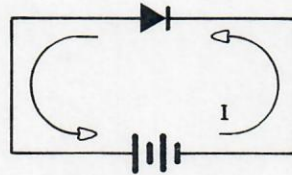
12. $R_{\text{bulk}} = \frac{\Delta V_F}{\Delta I_F} = \frac{\Delta V_F}{(8) - (2)} \times 10^3$

$$R_{\text{bulk}} = \frac{(0.442) - (0.318)}{0.006} = \frac{(0.124)}{0.006} = \underline{20.66} \Omega$$

Assignment

1. a
2. b
3. c
4. d

5.



Experiment No. 2 - Diode Characteristic Oscilloscope Display

Procedure

3.

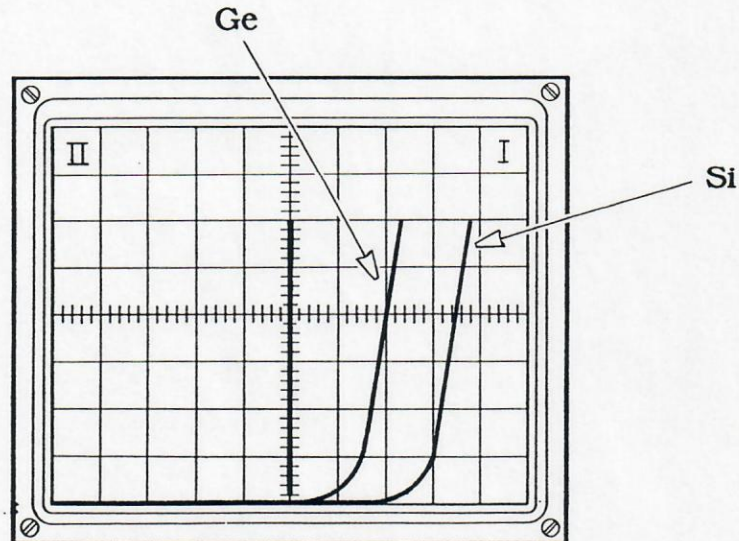


Figure 2 - Display of quadrants I and II.

$V_F \text{ at } 50 \text{ mA} = 0.35$

$V_F \text{ at } 30 \text{ mA} = 0.30$

$R_{\text{bulk}} = \frac{\Delta V_F}{\Delta I_F} = \frac{0.05}{0.02} \times 10^{-3} \Omega$

$R_{\text{bulk}} = \frac{(0.35 - 0.30)}{(0.05 - 0.03)} \times 10^{-3} \Omega$

$V_F \text{ at } 7 \text{ mA} = 0.40$

$V_F \text{ at } 4 \text{ mA} = 0.38$

$R_{\text{bulk}} = \frac{\Delta V_F}{\Delta I_F} = \frac{0.02}{0.03} \times 10^{-3} \Omega$

$R_{\text{bulk}} = \frac{(0.40 - 0.38)}{(0.07 - 0.04)} \times 10^{-3} \Omega$

Assignment

1. a
2. b
3. c
4. d



Experiment No. 3 - Diode Characteristics and Rectification

Procedure

3.

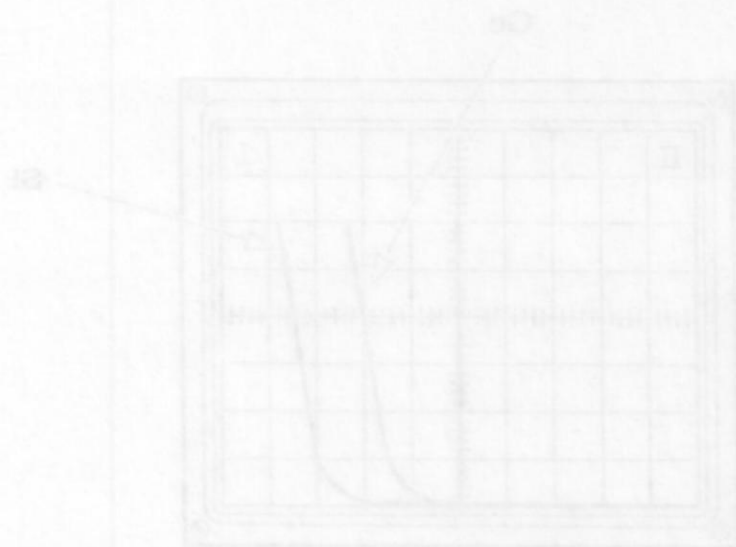
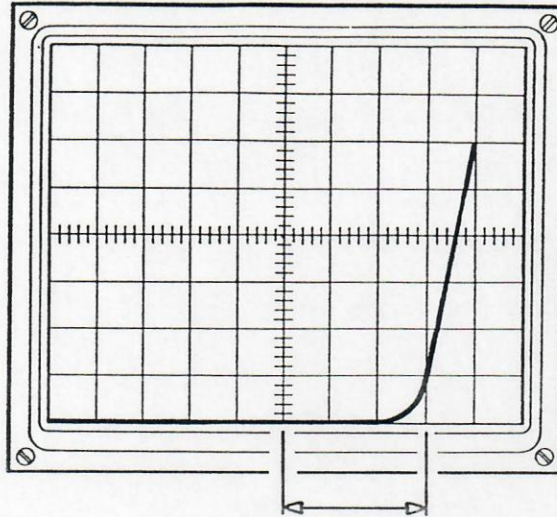


Figure 3 - Display of forward bias and I.

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5.



$$V_{B Si} = (0.2)(3.25) = 0.65$$

How close is the measured forward voltage to 0.7 volts? Very close.

7. $V_{B Ge} = 0.3V$

How close is the measured forward voltage to 0.3 volts? Very close.

12.

f (Hz)	TIME/DIV	OUTPUT WAVEFORMS		Vout Si	Vout Ge
		Si	Ge		
60	2 mS			1.2V	1.3V
100	2 mS			1.2V	1.3V
200	1 mS			1.2V	1.3V
400	0.5 mS			1.2V	1.3V
1 kHz	0.1 mS			1.2V	1.3V
5 kHz	20 μS			1.2V	1.3V
10 kHz	10 μS			1.2V	1.3V
50 kHz	5 μS			0.9V	1.3V
100 kHz	2 μS			0.7V	1.4V

TABLE 1 - Diode output waveforms and dc output voltages versus input frequency.

Assignment

1. c
2. c
3. a
4. Matching

d	IF
a	VR
e	piv

- | | |
|---|-----|
| f | trr |
| c | IR |
| b | VF |

Experiment No. 3 - Half-Wave Rectifier Circuit Operation**Procedure**

2. AC Input Voltage to Rectifier = 10.3v
3. Theoretical Vdc = (10.3) (0.45) = 4.6V
4. DC Output Voltage = 4.4V

Compare the measured dc output to the theoretical dc output voltage calculated in step 3. How close are the two voltages?

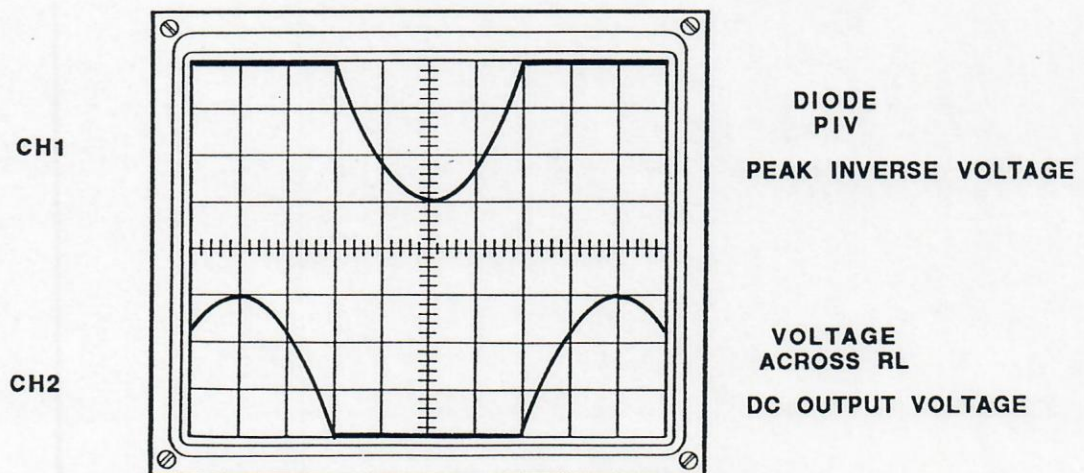
Measured is lower due to the diode drop but still very close to calculated value.

5. Output Voltage Polarity: A = + B = -
6. Output Voltage Polarity: A = - B = +
(D4 Reversed)

Compare the polarity to that measured in step 5. Explain the results.

The DC polarity reverses when the diode is reversed because the current now flows in the reverse direction.

10.



Half-wave rectifier waveforms.

Assignment

1. V_{in}
2. V_{out}
3. V_{in}
4. V_{out}

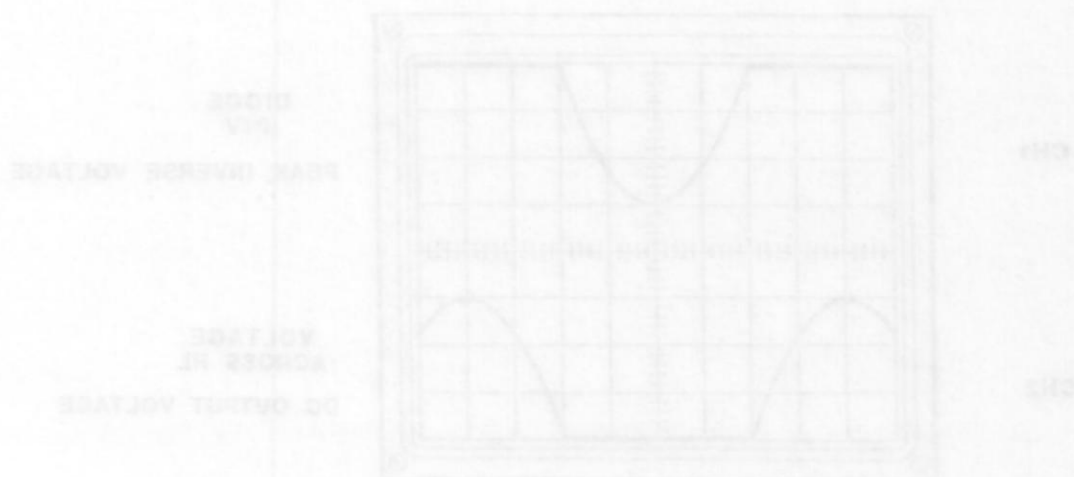
1. V_{in}
2. V_{out}
3. V_{in}
4. V_{out}

Experiment No. 3 - Half-Wave Rectifier Circuit Operation

Procedure

1. AC Input Voltage = 10.0V
2. Theoretical $V_{out} = (V_{in}) / 2 = 5.0V$
3. DC Output Voltage = 5.0V
4. Connect the measured DC output to the theoretical DC output voltage calculated in step 2. How close are the two voltages?
5. Disconnect the load from the circuit and measure the open-circuit voltage.
6. Output Voltage: Polarity A = +, B = -
7. Output Voltage: Polarity A = -, B = +
8. Compare the polarity to that measured in step 6. Explain the results.
9. The DC output voltage when the load is removed is referred to as the no-load voltage.

10.



Half-wave rectifier waveforms

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11. Measured PIV = $(3)(5) = \underline{15V}$

12. Theoretical PIV = $(10.3)(1.414) = \underline{14.56V}$

Compare the measured piv to the calculated piv above. How close are they? Very close.

13. Measured Peak dc Output = $(3)(5) = \underline{15V}$

14. Theoretical Peak dc Output = $(10.3)(1.414) = \underline{14.56V}$

How do the theoretical and measured peak output voltages compare? Very close.

15. $f = 1 / [(3.3)(0.005)] = \underline{60.6 \text{ Hz}}$

Assignment

1. c $V_{DC \text{ av}} = (v_{ac})(0.45) = (24)(0.45) = \underline{10.8V}$
2. b $V_{pkRL} = (v_{ac})(1.414) = (24)(1.414) = \underline{33.9V}$
3. b $V_{pk D1} = (v_{ac})(1.414) = (24)(1.414) = \underline{33.9V}$
4. c $f_{\text{ripple}} = f_{\text{line}} = \underline{50 \text{ Hz}}$
5. b
6. c $f = 1/T = 1/0.02 = \underline{50 \text{ Hz}}$
7. a
8. d $cm = (v_{ac} \times 1.414 \times 2) / (V_{\text{per cm}}) = 67.87/10 = \underline{6.78 \text{ cm}}$
9. c
10. b

Experiment No. 4 - Full-Wave Rectifier Circuit Operation

Procedure

2. AC Input Voltage to Diode D3 = 10.5V
3. Theoretical DC Output = $(10.5)(0.9) = \underline{9.45V}$
4. Measured DC Output Voltage = 8.77

Compare the measured and calculated values of the dc output. Are they close in value?

Yes, less the 0.7V diode drop.

11. Measured $V_{in} = 12.85 \text{ V}$

12. Theoretical $V_{in} = (60.38 \text{ V}) = 12.85 \text{ V}$

Compare the measured V_{in} to the calculated V_{in} . How close are they? Very close.

13. Measured Peak-to-Peak $V_{out} = 12.85 \text{ V}$

14. Theoretical Peak-to-Peak $V_{out} = (10.88 \text{ V}) = 12.85 \text{ V}$

How do the theoretical and measured peak output voltages compare? Very close.

15. $V_{in} = 12.85 \text{ V}$

Assignment

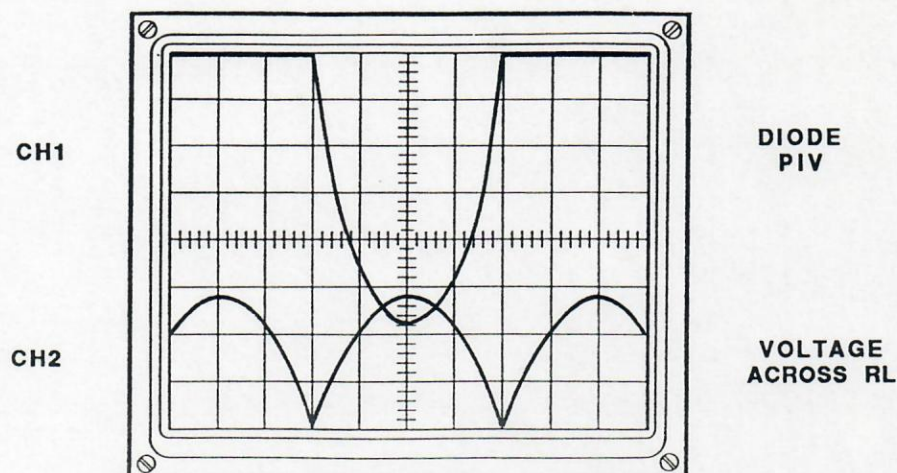
1. $V_{in} = 12.85 \text{ V}$
2. $V_{in} = 12.85 \text{ V}$
3. $V_{in} = 12.85 \text{ V}$
4. $V_{in} = 12.85 \text{ V}$
5. $V_{in} = 12.85 \text{ V}$
6. $V_{in} = 12.85 \text{ V}$
7. $V_{in} = 12.85 \text{ V}$
8. $V_{in} = 12.85 \text{ V}$
9. $V_{in} = 12.85 \text{ V}$
10. $V_{in} = 12.85 \text{ V}$

Experiment No. 4 - Full-Wave Rectifier Circuit Operation

Procedure

1. AC Input Voltage to Bridge $V_{in} = 12.85 \text{ V}$
 2. Theoretical DC Output $V_{out} = 10.88 \text{ V}$
 3. Measured DC Output Voltage $V_{out} = 12.85 \text{ V}$
- Compare the measured and calculated values of the dc output. Are they close to each other?
- Yes, they are the 12.85 V.

6.



7. Place switch SA DOWN for half-wave operation and describe the change in the output waveform and the dc level.

Every other half cycle of dc output is lost changing the ripple frequency from 120Hz to 60Hz and the dc output drops to 4.2V.

9. $PIV = (\text{No of Div}) (5) = (6) (5) = \underline{30V}$
10. $PIV, \text{Half-Wave Operation} = (3)(5) = \underline{15V}$
11. $f = 1 / T = 1 / (0.0083)$

FW Ripple Frequency = 120.48 Hz

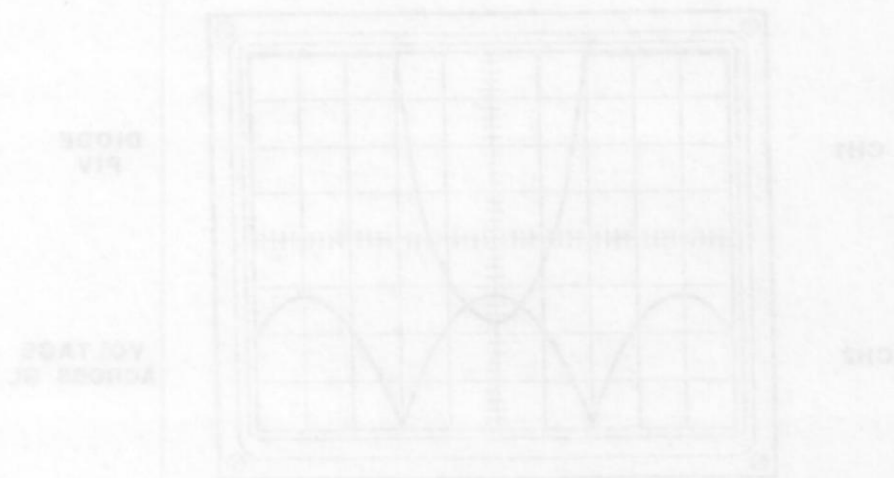
Compare the full-wave ripple frequency to that generated by the half-wave rectifier.

Full-wave ripple frequency is twice that of the half-wave ripple frequency.

13. Calculated $V_{dc \text{ av}} = (20) (0.9) = \underline{18V}$
14. Measured $V_{dc \text{ av}} = \underline{18V}$

How close are the measured and theoretical calculated dc output voltages? The same.

15. Is half-wave or full-wave operation indicated by the waveform across RL? Full-wave operation.



Place switch SA DOWN for half-wave operation and observe the change in the output waveform and the dc level.

Every other half cycle of the output is lost when the ripple frequency is 120 Hz and the output drops to 0 V.

$$V_{AV} = \text{Vdc of Out} = 1.61 \text{ V} = 30\text{V}$$

$$V_{AV} \text{ Half-Wave Operation} = 1.57V = 30V$$

$$f = 1/T = 1/0.00833 = 120 \text{ Hz}$$

$$f_{\text{ripple frequency}} = 120 \text{ Hz}$$

Compare the half-wave ripple frequency to that generated by the half-wave rectifier.

Half-wave ripple frequency is twice that of the full-wave ripple frequency.

$$\text{Calculated } V_{dc} = 1.61 \text{ V} = 30\text{V}$$

$$\text{Measured } V_{dc} = 1.61 \text{ V}$$

How close are the measured and theoretical calculated dc output voltages?

Is half-wave or full-wave operation indicated by the waveform across R1? Full-wave operation.

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16. $V_{dc\ pk} = \underline{28\ volts}$

17. $piv\ D1\ \underline{30V}$ $piv\ D2\ \underline{30V}$ $piv\ D3\ \underline{30V}$ $piv\ D4\ \underline{30V}$

Assignment

1. b
2. c
3. c
4. d $Av\ dc\ FW = (v_{sec}/2)(0.9) = (24/2)(0.9) = \underline{10.8V}$
5. a
6. b $Av\ dc\ BR = (v_{sec})(0.9) = (12.6)(0.9) = \underline{11.3V}$
7. c $f_{ripple} = 2\ f_{line} = (2)(60) = \underline{120\ Hz}$
8. c
9. a

Experiment No. 5 - Filter Circuit Operation

Procedure

2. Unfiltered HW DC Output Voltage = 4.3V
3. Unfiltered HW AC Output Voltage = 5.5 Vac
4. Ripple = $[(5.5) / (4.3)]\ 100\% = \underline{127.9\%}$

Does the ripple percentage exceed 100% as explained in Information Sheet 3?

Yes

6. HW PIV Without Filter = 15V
8. HW PIV With Filter = 28.5V

How has the peak inverse voltage been affected by the addition of a filter capacitor?

Doubled

9. Output Voltages With 10 μF Filter:

$v_{out\ rms} = \underline{0.53V}$ $V_{out\ DC} = \underline{12.5V}$

10. Ripple = $[(0.53) / (12.5)]\ 100\% = \underline{4.24\%}$

How does the addition of the filter capacitor affect the ripple level in the output?

Reduced it drastically.

18. $V_{dc} = 28 \text{ volts}$

19. $P_{in} = 10 \text{ W}$ $P_{out} = 8 \text{ W}$ $P_{loss} = 2 \text{ W}$

Assignment

- 1. d
- 2. c
- 3. c
- 4. $V_{dc} = 10 \text{ V}$ $V_{ac} = 10 \text{ V}$ $V_{rms} = 7.07 \text{ V}$
- 5. a
- 6. $V_{dc} = 10 \text{ V}$ $V_{ac} = 10 \text{ V}$ $V_{rms} = 7.07 \text{ V}$
- 7. $V_{dc} = 10 \text{ V}$ $V_{ac} = 10 \text{ V}$ $V_{rms} = 7.07 \text{ V}$
- 8. a

Experiment No. 5 - Filter Circuit Operation

Procedure

- 1. Unleaded HW AC Output Voltage = 4.5 V
- 2. Unleaded HW AC Output Voltage = 4.5 V
- 3. Ripple = 10.5 V (4.5 V) 100% = 12.5 V

Does the ripple percentage exceed 100% as explained in Information Sheet 3?

Yes

- 4. HW FV Without Filter = 12 V
- 5. HW FV With Filter = 2.5 V

How has the peak inverse voltage been affected by the addition of a filter capacitor?

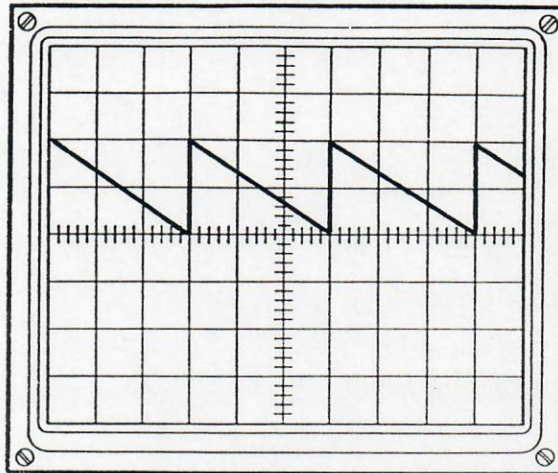
Reduced

- 6. Output Voltage With 10 μF Filter
Peak rms = 2.5 V Peak DC = 12.5 V
- 7. Ripple = 10.5 V (4.5 V) 100% = 12.5 V

How does the addition of the filter capacitor affect the ripple level in the output?

Reduced substantially

11.



P-P Ripple Voltage With 10 μF Filter = 2V p-p

12. Output Voltages With 100 μF Filter:

$$v_{\text{out rms}} = \underline{0.65\text{V}}$$

$$V_{\text{out DC}} = \underline{13\text{V}}$$

13. Ripple = $[(0.065) / (13)] 100\% = \underline{0.5\%}$

How does increasing the value of the filter capacitor from 10 μF to 100 μF affect the level of the ripple voltage in the output of the power supply?

Lowers the ripple still further to 0.5%

16. Output Voltages With FW Operation and a 100 μF Filter:

$$v_{\text{out rms}} = \underline{0.03\text{V}}$$

$$V_{\text{out DC}} = \underline{13.4\text{V}}$$

Ripple % With FW Rectification = 0.22%

How does converting from H-W to F-W rectification affect the ripple percentage?

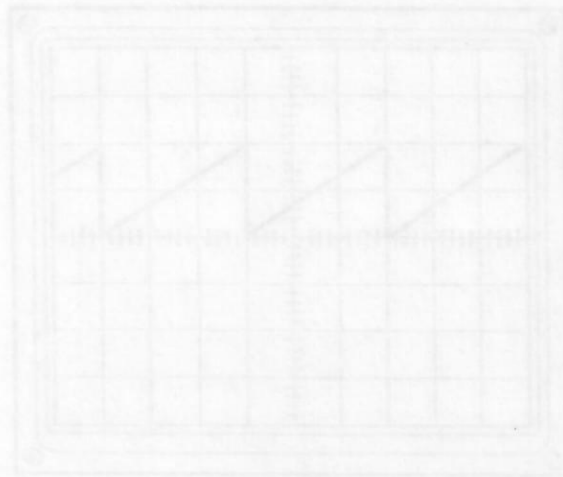
Reduces it by approximately half.

17. What is the effect upon the ripple voltage when the load current is increased?

The ripple level increases.

18. Ripple % with increased load = $[(0.115) / (12.6)]100 = \underline{0.9\%}$

11



7-V ripple voltage with 10 μ F filter = 32.9-V

Output voltage with 100 μ F filter

0 out rms = 0.65V
V out DC = 12V

12. Ripple = $10.68V \sqrt{1/30} \sqrt{1000} = 0.33V$

How does increasing the value of the filter capacitor from 10 μ F to 100 μ F affect the level of the ripple voltage in the output of the power supply?

Lower the ripple will be to 0.33V

13. Output voltage with 75 μ F capacitor and a 100 μ F filter

0 out rms = 0.65V
V out DC = 12.4V

Ripple is with 75 μ F capacitor = 0.33V

How does changing from 10 μ F to 75 μ F capacitor affect the ripple percentage?

Reduces it by approximately half

14. What is the effect upon the ripple voltage when the load current is increased?

The ripple level increases

15. Ripple is with increased load = $10.11V \sqrt{1/30} \sqrt{1000} = 0.33V$

Assignment

1. a $v_{sec} = (v_{pri})(TR) = (120)(1/5) = \underline{24v}$
 $V_{DC\ av} = (v_{sec})(0.45) = \underline{10.8V}$
2. d $PIV = (v_{sec})(1.414) = (24)(1.414) = \underline{33.93v}$
3. c
4. d $PIV\ HW\ with\ filter = (2)(v_{sec})(1.414) = (2)(24)(1.414) = \underline{67.8v}$
5. b $Ripple = (v_{ac}/V_{dc})100\% = (0.5/11)100 = \underline{4.545\%}$
6. b
7. b $V_{dc\ pk} = (v_{sec}/2)(1.414) = (24/2)(1.414) = \underline{16.97V}$
8. d

Experiment No. 6 - Diode Peak Repetitive and Surge Currents

Procedure

3. $I_{pk} = v_{pk}/100 = (0.16)/(100)$
 Peak Diode Current (Resistive Load) = 1.6 mA
4. Diode Conduction Angle (Capacitive Load) = 45°
5. $I_{FWD} = (V_{out\ dc}) / (R_L)$
 $I_{FWD} = (12.3) / (10,000) = \underline{1.23\ mA}$
6. $V_{pk} (100\Omega) = (No\ of\ Div) (V/Div) = (5.4) (0.2) = \underline{1.08V}$
 $I_{pk} = (V_{pk}) / (R_S) = (1.08) / (100) = \underline{10.8\ mA}$

Compare the Average Forward Diode Current, I_{FWD} , (Step 4) to the Peak Repetitive Forward diode current.

The peak repetitive current is approximately 8 times greater than the average forward current I_F .

8. In what way does the waveform change when the circuit is changed from half to full-wave operation?

The peak voltage drops almost by half and the number of current pulses double.

12. $V_{max} = (No\ of\ Div) (V/Div)$
 $V_{max} = (4.8) (2) = \underline{9.6V}$
13. $I_{surge} = (V_{rs\ max}) / (R_S) = (9.6) / (100) = \underline{96\ mA}$

Assignment

1. a
2. c
3. a
4. c
5. b $v_{pk} = (v_{rms})(1.414) = (120)(1.414) = \underline{169.68v}$
 $R_S = (v_{pk})/(I_{surge}) = 169.68/30 = \underline{5.65\Omega}$
 $R_S = 5.65\Omega - 0.65\Omega = \underline{5.0\Omega}$

Experiment No. 7 - Voltage Multiplier Circuit Operation**Procedure**

2. $VC1 = \underline{14.16V}$

3. $VC2 = \underline{14.15V}$

4. $V A \text{ to } C = \underline{28.3V}$

Calculate the sum of VC1 plus VC2 and record it below.

$VC1 + VC2 = \underline{28.31V}$

Compare the above sum to the A to C measurement. Are they both the same voltages? Yes

5. $v_{in \text{ rms}} = 10.5$

Calculate the peak input voltage from:

$v_{in \text{ pk}} = (v_{rms}) (1.414) = (10.5) (1.414) = \underline{14.85v}$

Is the dc output voltage measured in step 4 equal to twice the peak ac input voltage?

Slightly less due to the diode drop.

Is the circuit acting as a voltage doubler? Yes

8. $\text{Period} = (\text{No of Div}) (\text{TIME/DIV}) = (4.2) (2 \text{ mS}) = \underline{8.4 \text{ mS}}$

Convert the period to frequency using:

$f = 1 / \text{Period} = 1 / (0.0084) = \underline{119.06 \text{ Hz}}$

10. $C1 \text{ Voltage} = \underline{14.15V}$

11. $C2 \text{ Voltage} = \underline{28.3V}$

Check the peak ac input voltage measured in step 5. Is the dc output voltage measured across C2 twice the peak ac input? Very close.

13. $\text{Period} = \underline{16 \text{ mS}}$

Convert the period to frequency using:

$f = 1 / \text{Period} = 1 / (0.16) = \underline{62.5 \text{ Hz}}$

Experiment No. 7 - Voltage Multiplier Circuit Operation

Procedure

1. $V_{C1} = 14.15V$

2. $V_{C2} = 14.15V$

3. $V_{A \& C} = 28.3V$

Calculate the sum of V_{C1} plus V_{C2} and record it below.

$V_{C1} + V_{C2} = 28.3V$

Compare the above sum to the $A \& C$ measurement. Are they both the same voltage? Yes

4. $t_{in} = 10.5$

Calculate the peak input voltage from:

$V_{in(pk)} = (V_{avg} \times 1.414) = (10.5 \times 1.414) = 14.85V$

Is the output voltage measured in step 4 equal to twice the peak ac input voltage?

Slightly less due to the diode drop.

Is the circuit acting as a voltage doubler? Yes

5. Period = $(No. of Div) \times (Time/Div) = (4.51 \times 20s) = 90.2ms$

Convert the period to frequency using:

$f = 1 / \text{Period} = 1 / (0.0902s) = 11.097Hz$

10. $C1 \text{ Voltage} = 14.15V$

11. $C2 \text{ Voltage} = 28.3V$

Check the peak ac input voltage measured in step 5. Is the ac output voltage measured across $C2$ twice the peak ac input? Very close

12. Period = $90.2ms$

Convert the period to frequency using:

$f = 1 / \text{Period} = 1 / (0.0902s) = 11.097Hz$

14 - PART H1 ANSWER MANUAL

15. Expected Tripler Output $V_A \text{ to } B = (10.5)(3)(1.414) = \underline{44.5V}$

Measured Tripler Output $V_A \text{ to } B = \underline{42.2V}$

How close are the theoretical and measured tripler output voltages? Very close considering the diode drops.

16. Expected Tripler Ripple Frequency $f = \underline{60 \text{ Hz}}$

17. Measured Ripple Frequency $f = \underline{62.5 \text{ Hz}}$

Assignment

1. d $V_o = (2)(v_{sec})(1.414) = (2)(30)(1.414) = \underline{84.84V}$

2. c

3. b

4. a

5. c $T = 1/f \text{ where } f = 2(60) = 1/120 = \underline{8.33 \text{ mS}}$

6. d

7. b

8. d $V_o = (2)(v_{sec})(1.414) = (2)(70)(1.414) = \underline{197.96V}$

9. d

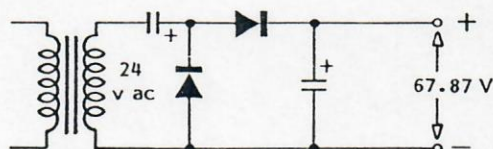
10. a

11. b

12. d $V_o = (3)(v_{sec})(1.414) = (3)(14)(1.414) = \underline{59.3V}$

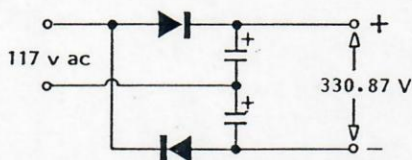
13. c $V_o = (2)(v_{sec})(1.414) = (2)(14)(1.414) = \underline{39.59V}$

14.



$$V_o = (2)(24)(1.414) = \underline{67.87V}$$

15.



$$V_o = (2)(117)(1.414) = \underline{330.8V}$$

12. Expected Output: $V_A \text{ to } B = 110.87091 \text{ V} = 44.34 \text{ V}$

Measured Output: $V_A \text{ to } B = 43.34 \text{ V}$

How close are the theoretical and measured output voltages? How close considering the above errors?

13. Expected Output Frequency: $f = 22.5 \text{ kHz}$

14. Measured Output Frequency: $f = 22.5 \text{ kHz}$

Assignment:

1. $V_o = (20 \text{ sec}) (1.414) = (28.284) = 28.284 \text{ V}$

2. $T = 1/f \text{ where } f = 2000 = 1/2000 = 5 \times 10^{-4} \text{ sec}$

3. $V_o = (20 \text{ sec}) (1.414) = (28.284) = 28.284 \text{ V}$

4. $V_o = (20 \text{ sec}) (1.414) = (28.284) = 28.284 \text{ V}$

5. $V_o = (20 \text{ sec}) (1.414) = (28.284) = 28.284 \text{ V}$



6. $V_o = (20 \text{ sec}) (1.414) = 28.284 \text{ V}$



7. $V_o = (20 \text{ sec}) (1.414) = 28.284 \text{ V}$

Experiment No. 8 - Power Supply Troubleshooting**Procedure**

2.

DIODE	Rfwd	Rrev
D1	80	∞
D2	82	∞

DIODE	Rfwd	Rrev
D3	80	∞
D4	80	∞

3.

DIODE	FORWARD	REVERSE
D4 Si	538 mV	1534 mV
D5 Ge	238 mV	1534 mV

DMM "Open" Reading = 1534 mV

How could you determine, from the voltage readings, which diode is germanium and which diode is silicon?

238 mV is close to 0.3 and is Ge; 538 mV is closest to 0.7 and is Si.

5.

DIODE	FORWARD	REVERSE
D4	4.5V	0V
D5	4.5V	0.1V

Which diode is Si and how were you able to determine this?

The Si diode dropped 0.5 volts while the Ge diode dropped the reading 0.3 volts.

Why is there a reverse reading for diode D5?

It is Ge and has higher leakage than Si diodes.

Why is the forward voltage reading higher than the reverse voltage reading?

The diode conducts on the forward polarity and the meter reads 5 volts less the diode drop.

7. Normal DC Output, $V_{out\ dc} = \underline{13.25V}$

Experiment No. 8 - Power Supply Troubleshooting

Procedure

DIODE	Rev'd	Rev
D1	80	-
D2	51	-
DIODE	Rev'd	Rev
D3	20	-
D4	80	-

DIODE	FORWARD	REVERSE
D1 S1	532 mV	1534 mV
D2 C4	238 mV	1534 mV

DIODE "Open" Reading = 1534 mV

How could you determine from the voltage readings which diode is germanium and which diode is silicon?

532 mV is close to 0.3 and 0.238 mV is closest to 0.7 and is

DIODE	FORWARD	REVERSE
D1	4.3V	0V
D2	4.3V	0.1V

Which diode is Si and how were you able to determine this?

The Si diode dropped 0.2 volts while the Ge diode dropped the reverse 0.3 volts.

Why is there a reverse reading for diode D2?

It is Ge and has higher reverse than Si diodes.

Why is the forward voltage reading higher than the reverse voltage reading?

The diode conducts on the forward polarity and the meter reads 0 volts less the diode drop.

Normal DC Output Volt dc = 12.5V

10. DC Output Measured on The Oscilloscope, $V_{out\ dc} = \underline{13.6V}$

Compare the dc measurement made using the oscilloscope to the meter reading in step 7. How close are the readings? Very close; only 0.35 volts difference in readings.

11. Half-Wave Ripple Output, $v_{ripple} = \underline{1v\ p-p}$

12. $v_{rms} = (v_{p-p} / 2) 0.707 = [(1) / 2] 0.707 = \underline{0.35\ v_{rms}}$

13. $f = 1 / T = 1 / (0.0166) = \underline{60.0\ Hz}$

14. DC Meter Reading with C2 Open, $V_{out\ dc} = \underline{13.25V}$

Scope Ripple Reading with C2 Open, $v_{out\ ac} = \underline{0.9\ v\ p-p}$

How are the output voltages affected?

DC is unaffected but the ripple increases from 0.45 v p-p to 0.9 v p-p.

15. $V_{out\ dc} = \underline{13V}$ (Meter Reading)

$v_{out\ ac} = \underline{0.84v\ p-p}$ (Scope Reading)

How are the output voltages affected?

Small drop in dc but an increase in the p-p ripple level from 0.45 to 0.88.

16. $V_{out\ dc} = \underline{12.8V}$ (Meter Reading)

$v_{out\ ac} = \underline{0.88v\ p-p}$ (Scope Reading)

17. $f_{ripple} = \underline{60Hz}$

18. $V_{out\ dc} = \underline{9.9V}$

$v_{out\ ac} = \underline{2.4v\ p-p}$

19. Explain why $v_{out\ ac}$, the ripple voltage, increases in value.

C2 discharge through R2/R3 resulting in a shorter time constant.

20. $V_{out\ dc} = \underline{11.2V}$

Explain why the two voltage readings, the dc output of the power supply and the dc output of the rectifiers, have dropped.

Because of the high current drain, C1 and C2 discharge more rapidly to produce a lower average dc.

22. TROUBLESHOOTING TABLE 1

FAULT #	SYMPTOMS	TROUBLESHOOTING PROCEDURE	DEFECT
1			
2			
3			
4			

30. Van de = 11.52

Explain why the two voltage readings for the output of the power supply and the output of the inductor have stopped.

Explain of the first current from C1 and C2. Explain the most likely to produce a low voltage.

III. TROUBLESHOOTING TABLE 1

TABLE 1. TROUBLESHOOTING TABLE 1	TABLE 1. TROUBLESHOOTING TABLE 1	TABLE 1. TROUBLESHOOTING TABLE 1
1		
2		
3		
4		

TROUBLESHOOTING TABLE 2

FAULT #	SYMPTOMS	TROUBLESHOOTING PROCEDURE	DEFECT
a	Increased ripple level. The ripple drops from 120 to 60 Hz. Slight dc drop (0.5).	Checked diodes for open Checked ac input to each diode	Open lead to D2
b	Ripple f drops to 60 Hz. DC output drops 0.5V	Checked ac input to diodes. No input to diode D1.	Shorted transformer secondary
c	Low DC output (1.2V). No ripple.	Checked dc on input side of 100 Ω , RF; Found full input (14V). 100 Ω resistor "open."	Open 100 Ω resistor
d	Increased Ripple Level, 0.8V p-p	Used two 5 μ F caps in parallel as a test capacitor. When C2 is paralleled, ripple drops back to normal.	Open C2

Assignment

1. a
2. d
3. d
4. b
5. c
6. b
7. a
8. d
9. d
10. c

TABLE 2 - TEST RESULTS

TEST	TEST RESULTS	DEFECT
1. High level 100 to 150 Hz 100 to 150 Hz 100 to 150 Hz 100 to 150 Hz	Checked as input to output Checked as input to output Checked as input to output Checked as input to output	Open input to output
2. High level 100 to 150 Hz 100 to 150 Hz 100 to 150 Hz	Checked as input to output Checked as input to output Checked as input to output Checked as input to output	Open input to output
3. Low level 100 to 150 Hz 100 to 150 Hz 100 to 150 Hz	Checked as input to output Checked as input to output Checked as input to output Checked as input to output	Open input to output
4. High level 100 to 150 Hz 100 to 150 Hz 100 to 150 Hz	Checked as input to output Checked as input to output Checked as input to output Checked as input to output	Open input to output

Assignment

1. a
2. b
3. c
4. d
5. e
6. f
7. g
8. h
9. i
10. j

Unit Test

Part H1 - Diodes and Power Supplies

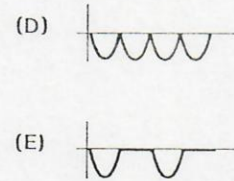
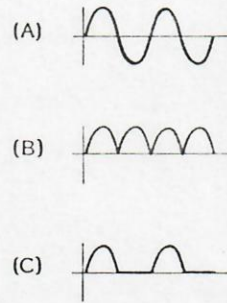
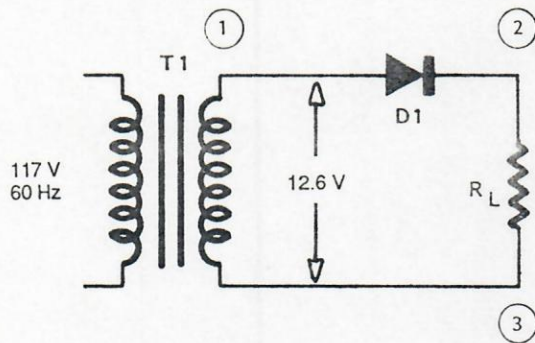
Unit Test

Part II - Dishes and Food Supplies

Part H1 - Diodes and Power Supplies

Unit Test

Answer the following multiple choice questions.



Questions 1 to 6 refer to Figure 1 above.

1. The turns ratio of T1 in Figure 1 is: _____
 - a 9.28:1 step down.
 - b 9.28:1 step up.
 - c 0.108 step down.
 - d none of the above.

2. The waveform across R_L in Figure 1 is: _____
 - a (B)
 - b (C)
 - c (D)
 - d (E)

3. The peak voltage that appears across D1 in Figure 1 is: _____
 - a 17.8V.
 - b 12.6V.
 - c 11.34V.
 - d 5.67V.

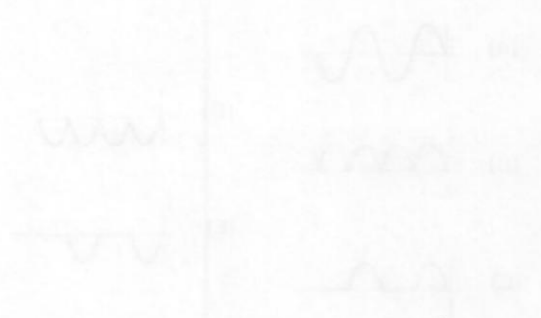
Part III - Diodes and Power Supplies

Unit Test

Answer the following multiple choice questions.



Questions 1 to 5 refer to Figure 1 above.



1. The turn ratio of T1 in Figure 1 is:

- a. 0.25:1 step down
- b. 0.25:1 step up
- c. 0.16:1 step down
- d. none of the above

2. The waveform across R1 in Figure 1 is:

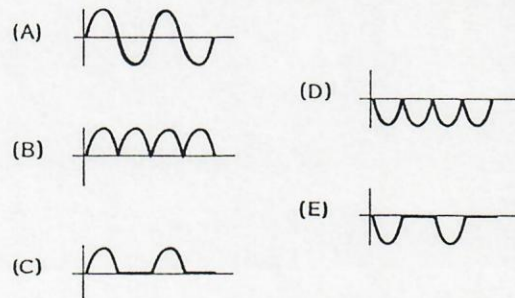
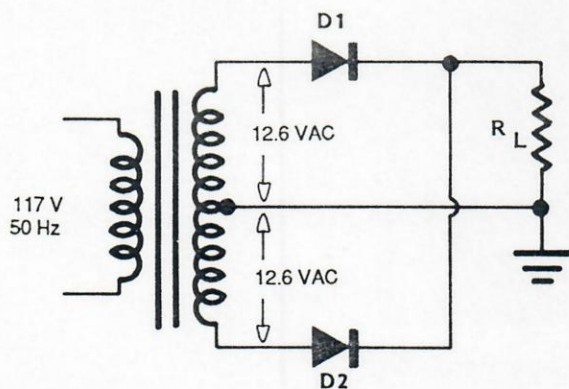
- a. (a)
- b. (c)
- c. (d)
- d. (b)

3. The peak voltage that appears across R1 in Figure 1 is:

- a. 17.8V
- b. 12.6V
- c. 11.34V
- d. 8.67V

2 - UNIT TEST FOR PART H1

4. The average DC voltage across R_L in Figure 1 is: _____
- 17.8V.
 - 12.6V.
 - 11.34V.
 - 5.67V.
5. The ripple frequency of the output in Figure 1 is: _____
- 30 Hz.
 - 60 Hz.
 - 120 Hz.
 - 30 or 60 Hz, depending upon the value of R_L .
6. The output polarity for the circuit of Figure 1 is: _____
- 1+, 2-.
 - 2-, 3+.
 - 2+, 3-.
 - constantly changing at a 60 Hz rate.



Questions 7 to 12 refer to Figure 2 above.

7. The circuit shown in Figure 2 is a: _____
- half wave rectifier.
 - half wave voltage doubler.
 - full wave rectifier.
 - full wave voltage doubler.

The average DC voltage across RL in Figure 1 is:

- a. 17.5V
- b. 15.0V
- c. 11.34V
- d. 8.5V

The ripple frequency of the output in Figure 1 is:

- a. 50 Hz
- b. 60 Hz
- c. 120 Hz
- d. 30 or 60 Hz depending upon the value of RL

The output polarity for the circuit in Figure 1 is:

- a. 1×2
- b. 2×2
- c. 2×1
- d. constantly changing at a 60 Hz rate



Questions 7 to 12 refer to Figure 2 above.

The circuit shown in Figure 2 is a:

- a. half wave rectifier
- b. full wave voltage doubler
- c. full wave rectifier
- d. full wave voltage doubler

8. The waveform that will appear across R_L in Figure 2 is: _____
- a (A)
 - b (B)
 - c (C)
 - d (D)
9. The ripple frequency in the output of Figure 2 is: _____
- a 50 Hz.
 - b 100 Hz.
 - c 60 Hz.
 - d 120 Hz.
10. The piv across each diode in Figure 2 is closest to: _____
- a 12.6V.
 - b 17.8V.
 - c 25.2V.
 - d 35.6V.
11. Waveform (A) in Figure 2 covers 4 vertical cm on the oscilloscope screen. The vertical gain control is set at 5V/Cm. The rms value of the voltage is: _____
- a 20V.
 - b 10V.
 - c 7.07V.
 - d 6.36V.
12. The average DC output voltage across R_L of Figure 2 is: _____
- a 11.34V.
 - b 12.6V.
 - c 7.07V.
 - d 6.36V.

8. The waveform that will appear across R_L in Figure 2 is _____

- a. (A)
- b. (B)
- c. (C)
- d. (D)

9. The ripple frequency in the output of Figure 2 is _____

- a. 30 Hz
- b. 100 Hz
- c. 60 Hz
- d. 120 Hz

10. The p-p voltage across each diode in Figure 2 is closest to _____

- a. 12.6V
- b. 17.9V
- c. 28.2V
- d. 35.6V

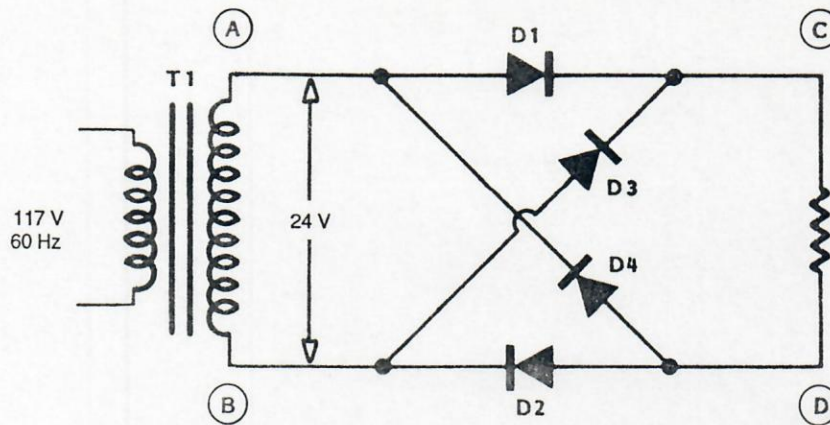
11. Waveform (A) in Figure 2 across a vertical cm on the oscilloscope screen. The vertical gain control is set at 5V/cm. The rms value of the voltage is _____

- a. 20V
- b. 10V
- c. 7.07V
- d. 6.38V

12. The average DC output voltage across R_L in Figure 2 is _____

- a. 11.34V
- b. 12.5V
- c. 7.07V
- d. 8.58V

4 - UNIT TEST FOR PART H1



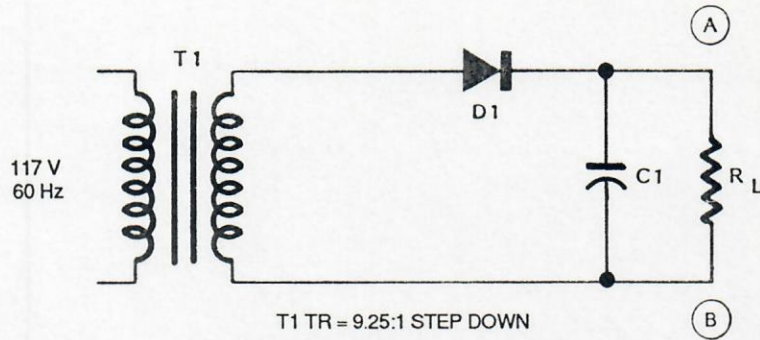
Questions 13 to 17 refer to Figure 3 above.

13. The circuit shown in Figure 3 is a: _____
 a. voltage doubler.
 b. full wave rectifier.
 c. bridge rectifier.
 d. improperly drawn.
14. The average DC output voltage in Figure 3 is: _____
 a. 15.3V.
 b. 21.6V
 c. 24V.
 d. 34V.
15. The piv seen by each diode in Figure 3 is: _____
 a. 34V.
 b. $34V/4$ or 8.5V each.
 c. 24V.
 d. 21.6V.
16. When point B in Figure 3 is positive with respect to point A, the diodes that conduct are: _____
 a. D1 and D2.
 b. D2 and D3.
 c. D3 and D4.
 d. D4 and D1.
17. For the circuit shown in Figure 3, the output polarity will be: _____
 a. A-, B+.
 b. A-, C+.
 c. C+, B-.
 d. C+, D-.



Questions 15 to 17 refer to Figure 2 above.

15. The circuit shown in Figure 2 is a
- bridge rectifier
 - full-wave rectifier
 - half-wave rectifier
 - inverter
16. The average DC output voltage in Figure 2 is
- 1.2V
 - 2.4V
 - 3.6V
 - 4.8V
17. The rms value of each diode in Figure 2 is
- 3.6V
 - 3.6V or 5.0V each
 - 2.4V
 - 1.2V
18. When point B in Figure 2 is positive with respect to point A, the diodes that conduct are
- D1 and D2
 - D3 and D4
 - D1 and D4
 - D2 and D3
19. For the circuit shown in Figure 2, the output polarity will be
- A-B
 - A-C
 - C-B
 - C-D



Questions 18 to 26 refer to Figure 4 above.

18. The piv that will appear across D1 in Figure 4 is closest to: _____
- 12.6V.
 - 15.75.
 - 17.8V.
 - 35.6V.
19. The AC and DC output from points A to B in Figure 4 measure 3.0 volts AC and 17 volts DC. The ripple percentage is: _____
- 17.6%.
 - 5.6%.
 - 1.76%.
 - 0.176%.
20. The power supply shown in Figure 4 has an unloaded output voltage of 15V and a full load output of 14.5V. The regulation percentage is closest to: _____
- 0.34%.
 - 1.034%.
 - 3.44%.
 - 9.66%.
21. The internal resistance of the power supply of Figure 4, given an unloaded V_o of 15V and an output of 14.5V when loaded by a 1K resistance, is closest to: _____
- 1000 Ω .
 - 34.5 Ω .
 - 50 Ω .
 - 145 Ω .



FIGURE 1: RELAY CIRCUIT

18. The relay will operate when the switch is closed.

- a. 12.5V
- b. 15.7V
- c. 17.5V
- d. 22.5V

19. The AC and DC output from points A to B in Figure 2 measure 2.0 volts AC and 1V volts DC. The ripple percentage is:

- a. 17.6%
- b. 5.5%
- c. 1.76%
- d. 0.176%

20. The power supply shown in Figure 3 has an unregulated output voltage of 12V and a full load output of 14.5V. The regulation percentage is closest to:

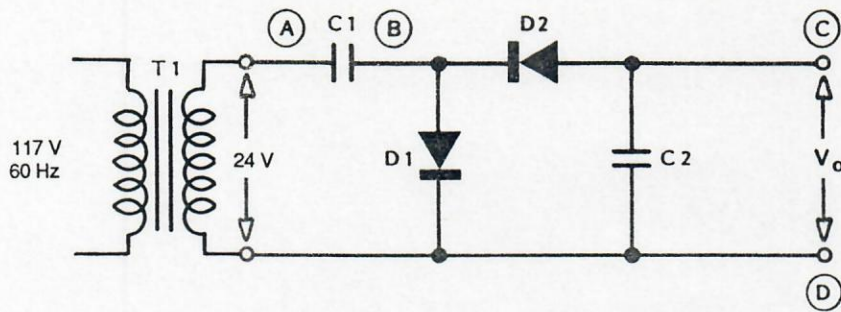
- a. 0.34%
- b. 1.084%
- c. 3.41%
- d. 3.89%

21. The internal resistance of the power supply of Figure 4 given an unloaded V_o of 12V and an output of 14.5V when loaded by a 1K resistance is closest to:

- a. 1000Ω
- b. 44.5Ω
- c. 20Ω
- d. 1.45Ω

6 - UNIT TEST FOR PART H1

22. The conduction angle for diode D1 in Figure 4, is: _____
- a 180°.
 - b more than 180°.
 - c less than 180°.
 - d 0°.
23. The ripple level of the power supply in Figure 4 can be improved by adding a: _____
- a pi LC filter section.
 - b pi RC filter section.
 - c voltage regulator.
 - d all of the above.
24. The diode surge current in the circuit of Figure 4 flows: _____
- a on every conducting half cycle.
 - b during each non-conducting half cycle.
 - c for the first few conducting half cycles.
 - d none of the above.
25. If capacitor C1 in Figure 4 were removed, the: _____
- a diode conduction angle would be 180°.
 - b diode surge current would not occur.
 - c voltage output would drop to 0.45 of V_{sec} .
 - d all of the above.
26. A diode surge limiting resistor could be added to the circuit of Figure 4 by inserting it: _____
- a between the T1 secondary and D1.
 - b in series with RL.
 - c across RL.
 - d none of the above.



Questions 27 to 30 refer to Figure 5 above.

27. The circuit shown in Figure 5 is a: _____
- full wave voltage doubler.
 - bridge doubler.
 - current regulator.
 - half wave voltage doubler.
28. For the secondary voltage shown in Figure 5, V_o will be closest to: _____
- 24V.
 - 34V.
 - 48V.
 - 68V.
29. The ripple frequency of the circuit of Figure 5 is: _____
- 30 Hz.
 - 60 Hz.
 - 120 Hz.
 - 180 Hz.
30. The piv that appears across D1 in Figure 5 is: _____
- 24V.
 - 34V.
 - 48V.
 - 68V.
31. As the multiplying factor is increased in a voltage multiplier design, the: _____
- regulation deteriorates.
 - ripple level increases.
 - voltage output increases.
 - all of the above.



Questions 27 to 30 refer to Figure 2 above.

27. The circuit shown in Figure 2 is a
- full-wave voltage doubler
 - bridge doubler
 - current regulator
 - full-wave voltage doubler
28. For the secondary voltage shown in Figure 2, V_s will be closest to
- 24V
 - 84V
 - 48V
 - 68V
29. The ripple frequency of the output of Figure 2 is
- 50 Hz
 - 60 Hz
 - 120 Hz
 - 180 Hz
30. The peak voltage across D1 in Figure 2 is
- 24V
 - 84V
 - 48V
 - 68V
31. As the multiplying factor is increased in a voltage multiplier design, the
- regulation deteriorates
 - ripple level increases
 - voltage output increases
 - all of the above

8 - UNIT TEST FOR PART H1

32. Voltage multipliers may be used when: _____
- a. improved regulation is necessary.
 - b. the available AC input voltage is too low for a bridge or half wave rectifier circuit.
 - c. superior ripple percentage figures are needed.
 - d. all of the above.
33. Draw the circuit of a full wave rectifier feeding a pi LC filter network.
34. Draw the circuit of a full wave voltage doubler.
35. Draw the circuit of a bridge rectifier with a pi LC capacitor filter.

32. Voltage measurements may be used when:

- a. improved regulation is necessary.
- b. the available AC input voltage is too low for a bridge or half-wave rectifier circuit.
- c. superior ripple percentage figures are needed.
- d. all of the above.

33. Draw the circuit of a full-wave rectifier feeding a pi LC filter network.

34. Draw the circuit of a full-wave voltage doubler.

35. Draw the circuit of a bridge rectifier with a pi LC capacitor filter.

Name _____ Class _____ Date _____

Unit Test H1 - Answer Sheet

- | | | | |
|----------|-----------|-----------|-----------|
| 1. _____ | 9. _____ | 17. _____ | 25. _____ |
| 2. _____ | 10. _____ | 18. _____ | 26. _____ |
| 3. _____ | 11. _____ | 19. _____ | 27. _____ |
| 4. _____ | 12. _____ | 20. _____ | 28. _____ |
| 5. _____ | 13. _____ | 21. _____ | 29. _____ |
| 6. _____ | 14. _____ | 22. _____ | 30. _____ |
| 7. _____ | 15. _____ | 23. _____ | 31. _____ |
| 8. _____ | 16. _____ | 24. _____ | 32. _____ |

33.

34.

35.

Name _____

Class _____

Date _____

Unit Test #1 - Answer Sheet

1	_____	9	_____	17	_____	25	_____
2	_____	10	_____	18	_____	26	_____
3	_____	11	_____	19	_____	27	_____
4	_____	12	_____	20	_____	28	_____
5	_____	13	_____	21	_____	29	_____
6	_____	14	_____	22	_____	30	_____
7	_____	15	_____	23	_____	31	_____
8	_____	16	_____	24	_____	32	_____

33

34

35

Part H1 - Diodes and Power Supplies
Unit Test
Instructor's Answer Sheet

1. a $TR = \frac{V_{pri}}{V_{sec}} = \frac{117}{12.6} = \underline{9.28:1}$
2. b (C)
3. a
$$\begin{aligned}piv &= V_{sec} \times 1.414 \\&= 12.6 \times 1.414 \\&= \underline{17.816V}\end{aligned}$$
4. d
$$\begin{aligned}V_{DC} &= V_{sec} \times 0.45 \\&= 12.6 \times 0.45 \\&= \underline{5.67V}\end{aligned}$$
5. b For 1/2 wave rectification:
 $f_{ripple} = f_{line} = 60 \text{ Hz}$
6. c 2+, 3-
7. c Full wave rectifier.
8. b (B)
9. b For full wave rectification.
$$\begin{aligned}f_{ripple} &= 2 f_{line} \\&= 2 \times 50 \\&= \underline{100 \text{ Hz}}\end{aligned}$$
10. d
$$\begin{aligned}piv &= V_{sec} \times 1.414 \\&= 25.2 \times 1.414 \\&= \underline{35.63V}\end{aligned}$$
11. c
$$\begin{aligned}V_{App} &= C_m \times V/C_m \\&= 4 \times 5 \\&= 20V_{pp} \\V_{rms} &= (20/2) 0.707 \\&= \underline{7.07V}\end{aligned}$$

Part II - Diodes and Power Supplies Unit Test Instructor's Answer Sheet

1. a. $IR = \frac{50V}{1.5A} = 33.3\Omega$

b. $IR = 10V$

3. a. $P_{AV} = 0.5 \times 1.414 = 0.707W$
 $P_{AV} = 0.707W$
 $P_{AV} = 0.707W$

b. $V_{AV} = 10V \times 0.707 = 7.07V$
 $V_{AV} = 7.07V$
 $V_{AV} = 7.07V$

5. b. For 1/2 wave rectification:
 $V_{AV} = \frac{V_m}{\pi} = 60V$

c. $V_{AV} = 30V$

7. c. Full wave rectifier.

d. $V_{AV} = 10V$

9. b. For full wave rectification:
 $V_{AV} = \frac{2V_m}{\pi} = 120V$
 $V_{AV} = 120V$
 $V_{AV} = 120V$

10. d. $P_{AV} = V_{AV} \times I_{AV} = 20V \times 1.414A = 28.28W$
 $P_{AV} = 28.28W$
 $P_{AV} = 28.28W$

11. c. $V_{AV} = 0.707 \times V_m = 4.24V$
 $V_{AV} = 4.24V$
 $V_{AV} = 4.24V$
 $V_{AV} = 4.24V$

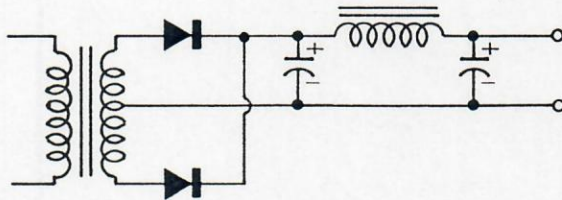
2 - UNIT TEST FOR PART H1 (ANSWERS)

12. a $V_{RL} = (v_{sec}/2) 0.9$
 $= (25.2/2) 0.9$
 $= \underline{11.34V}$
13. c bridge rectifier
14. b $V_{RL} = v_{sec} \times 0.9$
 $= 24 \times 0.9$
 $= \underline{21.6V}$
15. a $piv = v_{sec} \times 1.414$
 $= \underline{33.93V}$
16. c D3 and D4
17. d C+, D-
18. d $piv = v_{sec} \times 1.414 \times 2$
where $v_{sec} = v_{pri}/9.25 = 117/9.25 = 12.6$
 $piv = 12.6 \times 1.414 \times 2$
 $= \underline{35.6V}$
19. a % Ripple $= (v_{AC}/V_{DC}) \times 100$
 $= (3/17) \times 100$
 $= \underline{17.6\%}$
20. c % Regulation $= \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$
 $= \frac{15 - 14.5}{14.5}$
 $= \underline{3.44\%}$
21. b $R_i = \frac{R_L (V_{NL} - V_L)}{V_L}$
 $= \frac{1000 (15 - 14.5)}{14.5}$
 $= \underline{34.84\Omega}$
22. c less than 180°
23. d all of the above.
24. c For the first few conducting half cycles.

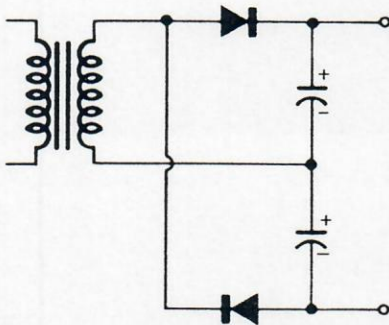
12	a	$V_{12} = 100 \times 0.9$ $= 90.0$ $= 11.34$
13	c	output condition
14	b	$V_{14} = 100 \times 0.9$ $= 90.0$ $= 11.34$
15	a	$V_{15} = 100 \times 1.14$ $= 114.0$
16	c	output condition
17	d	output condition
18	d	$V_{18} = 100 \times 1.14 \times 1.1$ $= 125.4$ $= 11.34 \times 1.1 = 12.474$ $= 12.474 \times 1.1 = 13.7214$ $= 13.7214 \times 1.1 = 15.09354$
19	a	$V_{19} = 100 \times 1.14 \times 1.1$ $= 125.4$ $= 11.34 \times 1.1 = 12.474$ $= 12.474 \times 1.1 = 13.7214$ $= 13.7214 \times 1.1 = 15.09354$
20	c	$V_{20} = 100 \times 1.14 \times 1.1$ $= 125.4$ $= 11.34 \times 1.1 = 12.474$ $= 12.474 \times 1.1 = 13.7214$ $= 13.7214 \times 1.1 = 15.09354$
21	a	$V_{21} = 100 \times 1.14 \times 1.1$ $= 125.4$ $= 11.34 \times 1.1 = 12.474$ $= 12.474 \times 1.1 = 13.7214$ $= 13.7214 \times 1.1 = 15.09354$
22	c	input condition
23	d	input condition
24	c	input condition

25. d all of the above.
26. a between the T1 secondary and D1.
27. d half wave voltage doubler.
28. d $V_{oNL} = 2 \times v_{sec} \times 1.414$
 $= 2 \times 24 \times 1.414$
 $= \underline{67.87V}$
29. b For half wave:
 $f_{ripple} = f_{line} = 60 \text{ Hz}$
30. d $piv = v_{in} \times 1.414 \times 2$
 $= 24 \times 1.414 \times 2$
 $= \underline{67.87V}$
31. d all of the above.
32. b the available AC input voltage is too low for a bridge or half wave circuit.

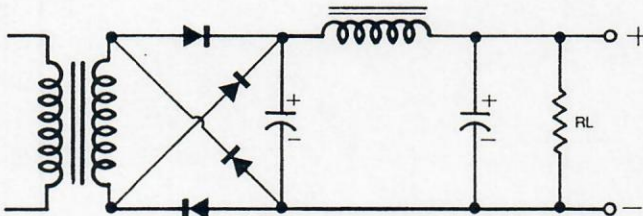
33.



34.



35.



35. d All of the above.
36. a between the T₁ secondary and D₁.
37. d half-wave voltage doubler.
38. d $V_{out} = 2 \times V_{in} \times 1.414$
 $= 2 \times 20 \times 1.414$
 $= 56.56V$
39. b Full-wave
 $I_{avg} = I_{rms} = 100mA$
40. d $P_{av} = P_{rms} = 1.414 \times 2$
 $= 2.828 \times 2$
 $= 5.656W$
41. d All of the above.
42. b the average AC input voltage is too low for a bridge or half-wave circuit.

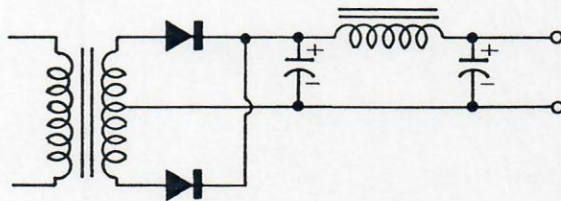


Name _____ Marking Key _____ Class _____ Date _____

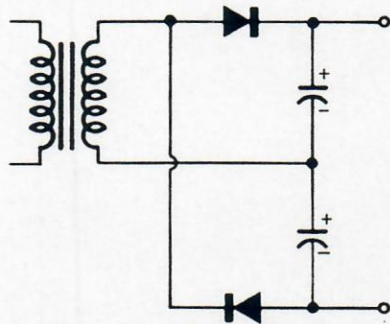
Unit Test H1 - Answer Sheet

- | | | | |
|-------------|--------------|--------------|--------------|
| 1. <u>a</u> | 9. <u>b</u> | 17. <u>d</u> | 25. <u>d</u> |
| 2. <u>b</u> | 10. <u>d</u> | 18. <u>d</u> | 26. <u>a</u> |
| 3. <u>a</u> | 11. <u>c</u> | 19. <u>a</u> | 27. <u>d</u> |
| 4. <u>d</u> | 12. <u>a</u> | 20. <u>c</u> | 28. <u>d</u> |
| 5. <u>b</u> | 13. <u>c</u> | 21. <u>b</u> | 29. <u>b</u> |
| 6. <u>c</u> | 14. <u>b</u> | 22. <u>c</u> | 30. <u>d</u> |
| 7. <u>c</u> | 15. <u>a</u> | 23. <u>d</u> | 31. <u>d</u> |
| 8. <u>b</u> | 16. <u>c</u> | 24. <u>c</u> | 32. <u>b</u> |

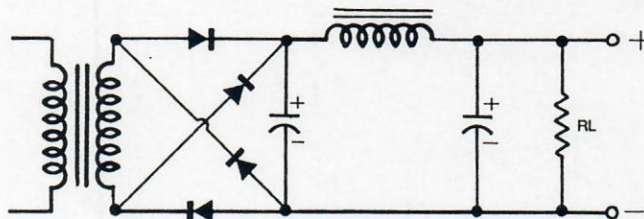
33.



34.



35.



Unit Test H1 - Answer Sheet

1. <u>a</u>	9. <u>b</u>	17. <u>d</u>	25. <u>d</u>
2. <u>b</u>	10. <u>d</u>	18. <u>d</u>	26. <u>a</u>
3. <u>a</u>	11. <u>c</u>	19. <u>a</u>	27. <u>d</u>
4. <u>d</u>	12. <u>a</u>	20. <u>c</u>	28. <u>d</u>
5. <u>b</u>	13. <u>c</u>	21. <u>b</u>	29. <u>b</u>
6. <u>c</u>	14. <u>b</u>	22. <u>c</u>	30. <u>d</u>
7. <u>c</u>	15. <u>a</u>	23. <u>d</u>	31. <u>d</u>
8. <u>b</u>	16. <u>c</u>	24. <u>c</u>	32. <u>b</u>









Ed-Lab
Instructor's Manual
J1-TRANSISTORS
AND CIRCUITS

CES INDUSTRIES, INC.

1. The first step in the process is to identify the problem.



5d-Job

Instructor's Manual

11-TRANSISTORS

AND CIRCUITS

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Name _____

Class _____

School _____

Ed-Lab
Instructor's Manual
TRANSISTORS AND CIRCUITS
PART J1

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Page _____
Date _____
Name _____

Instruction Manual FRANKLIN AND GREGG FRT-1

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It is the policy of Franklin and Gregg, Inc. to provide the user with the most complete and accurate information possible regarding the use of the FRT-1. This manual is intended to provide the user with the necessary information to operate the FRT-1 safely and effectively. The user should read this manual carefully and follow the instructions provided. The FRT-1 is a precision instrument and should be handled with care. The user should always use proper technique when operating the FRT-1. The FRT-1 is designed to provide accurate measurements and should be used in a controlled environment. The user should always use the FRT-1 in accordance with the instructions provided in this manual. The FRT-1 is a valuable tool and should be used to its full potential. The user should always use the FRT-1 in a safe and responsible manner. The FRT-1 is a precision instrument and should be handled with care. The user should always use proper technique when operating the FRT-1. The FRT-1 is designed to provide accurate measurements and should be used in a controlled environment. The user should always use the FRT-1 in accordance with the instructions provided in this manual. The FRT-1 is a valuable tool and should be used to its full potential. The user should always use the FRT-1 in a safe and responsible manner.

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FRT-1-100-1
Franklin and Gregg, Inc.

PART J1-TRANSISTORS AND CIRCUITS

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THERMAL AND CIRCUITS
PART II

ANSWERS - J1 INFORMATION SHEET 1/LESSON 1

INFORMATION SHEET 1 - BIPOLAR TRANSISTORS

ASSIGNMENT

1. c In electronics, a passive device is defined as one that does not amplify.
2. b In electronics, an active device is one that amplifies.
3. d All of the above are active devices.
4. c A semiconductor material valence ring contains approximately 4 electrons.
5. d All of the above.
6. a The barrier potential developed across a silicon PN junction is 0.7 volts.
7. b When a transistor, used as an amplifier, is biased, the B-E junction is forward biased and B-C junction is reverse biased.
8. a In the circuit of Figure 16, the lamp will not light. (The PN junction is reverse biased).
9. d All of the above.
10. c In a transistor amplifier circuit a small base current controls a large collector current.
11. d All of the above.
12. a When manufacturing ICs, silicon oxide is used as an insulating material.
13. b The term Medium Scale Integration (MSI) refers to an IC that contains more than 10 circuits but less than 100 circuits.
14. c The term Large Scale Integration (LSI) refers to an IC that contains more than 100 circuits but less than 1,000 circuits.
15. a $50 \mu A$ $I_B = I_E - I_C = 3.05 - 3 = 0.05 \text{ mA} = 50 \mu A$
16. d All of the above.
a) $\beta = \frac{I_C}{I_B} = \frac{3,000 \mu A}{20 \mu A} = 150$ b) $H_{fe} = \beta = 150$
c) $I_E = I_B + I_C = 0.02 \text{ mA} + 3 \text{ mA} = 3.02 \text{ mA}$
17. a When constructing a bipolar transistor, the thinnest of the three sections is always the base.
18. b (a) = NPN and (b) = PNP.

LESSON J1 - TRANSISTOR TESTING METHODS

ASSIGNMENT

1. d All of the above.
2. a When an analog ohmmeter is connected across the base-emitter junction of a transistor and reads 250 K, it indicates that the junction is reverse biased.
3. c Both a and b. Transistors are formed in a PNP or NPN sequence.
4. d All of the above.
5. a When testing a transistor with an analog ohmmeter, the transistor may be assumed to be the equivalent of two diodes back-to back.

ANSWERS - J1 EXPERIMENT NO. 1

EXPERIMENT NO. 1 - TRANSISTOR TESTING

PROCEDURE

2. The lamp lights when the fingertips are wet.
3. Changing pressure produces a changing body resistance which causes a changing lamp intensity. Tighter pressure causes lower resistance and greater lamp intensity.
5. $R_{FWD} = 120 \Omega$; $R_{REV} = \infty \Omega$
6. $R_{FWD} = 110 \Omega$; $R_{REV} = \infty \Omega$
7.
 - (+C) $R = \infty \Omega$; (-C) $R = \infty \Omega$
 - Yes
 - No
9.
 - $V_{E-B FWD} = 639 \text{ mV}$; $V_{E-B REV} = 1330 \text{ mV}$
 - $V_{open} = 1330 \text{ mV}$
 - Answers will vary.
 - Si
10. $V_{C-B FWD} = 634 \text{ mV}$; $V_{C-B REV} = 1330 \text{ mV}$
11.
 - $V_{B-E FWD} = 275 \text{ mV}$; $V_{B-E REV} = 1330 \text{ mV}$
 - Ge; 275 mV
13. The meter reads 5 volts.
14.
 - $V_{FWD} = 4.4 \text{ V}$; $V_{REV} = 0 \text{ V}$
 - Si
15.
 - $V_{FWD} = 4.8 \text{ V}$; $V_{REV} = 0.1 \text{ V}$
 - Ge
 - Leakage
16. Answers will vary with selection of transistors.

TRANSISTOR NUMBER	TO NO.	BASE DIAGRAM	NPN/ PNP	Ge/ Si	GOOD/ BAD	METHODS USED
1. 2N375	TO-3		NPN	Ge		
2. 2N1605	TO-5		NPN	Ge		
3. 2N404	TO-5		PNP	Ge		
4. 2N3904	TO-92		NPN	Si		

TABLE 1 - Test results on discrete transistors.

ANSWERS - J1 EXPERIMENT NO. 1 (CONT)/LESSON 2

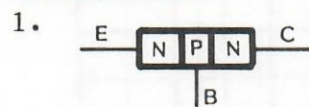
EXPERIMENT NO. 1 - TRANSISTOR TESTING (CONT)

ASSIGNMENT

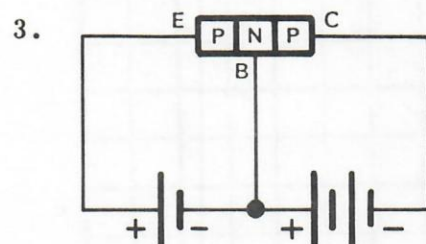
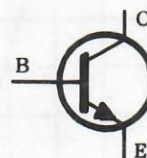
1. d Any of the above.
2. d All of the above.
3. a The transistor symbols shown in Figure 7 are (a) NPN (b) PNP.
4. c For the transistor symbols shown in Figure 7, the leads identified are; A-Base; B-Collector; C-Emitter.
5. d An analog ohmmeter connected from C to E of a transistor should read infinity in either direction because one junction is always reverse biased.
- 6 a A voltmeter used to measure the junction voltage drop caused by the ohmmeter will indicate a Si or Ge transistor.

LESSON 2 - TRANSISTOR VOLTAGES

ASSIGNMENT



2.



4. a) $\alpha_{dc} = \frac{I_C}{I_E}$

b) $\alpha_{dc} = \frac{\beta - 1}{\beta}$

5. $\beta_{dc} = \frac{I_C}{I_B}$

6. a) $\gamma = \frac{I_E}{I_B}$

b) $\gamma = \beta + 1$

ANSWERS - J1 EXPERIMENT NO. 2

EXPERIMENT NO. 2 - TRANSISTOR ACTION

PROCEDURE

2.

V_{in}	0	0.5	1	2	2.5	3	4	5	6	7	8	9
V_{out}	8.8	8.8	8	5.4	3.75	2.4	1.8	1.8	1.8	1.8	1.8	1.8

Table 1 - Test data for V_{out} versus V_{in} for the transistor circuit of Figure 1.

3.

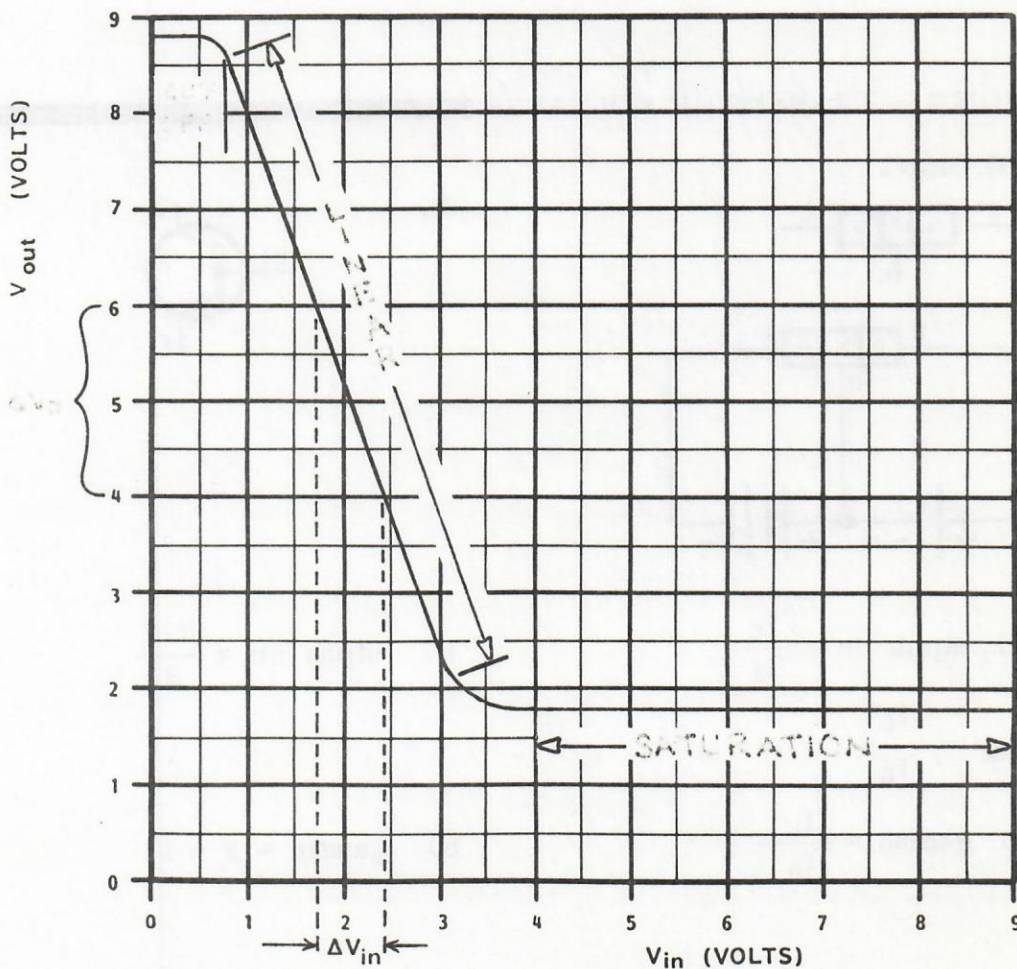


Figure 2 - Plot of V_{out} versus V_{in} for the transistor circuit of Figure 1.

4. •The current is maximum in the saturation region.

•Minimum.

6. $I_C = 0.9 \text{ mA}$

7. $I_E = 0.9 \text{ mA}$

ANSWERS - J1 EXPERIMENT NO. 2 (CONT)

EXPERIMENT NO. 2 - TRANSISTOR ACTION (CONT)

8. $I_B = 5 \mu A$
9. $\beta_{dc} = \frac{(0.9)}{(0.005)} \quad \beta_{dc} = 180$
 •Yes, Q6 beta is more than 100.
11. $\alpha_{dc} = \frac{(0.9)(-0.005)}{(0.9)} \quad \alpha_{dc} = 0.994$
 •Yes, Alpha is slightly less than 1.
12. $\Delta V_{in} = (2.4) - (1.7)$
13. $A_v = \frac{(6) - (4)}{(2.4) - (1.7)} = \frac{(2)}{(.7)} \quad A_v = 2.86$
 •Yes.

ASSIGNMENT

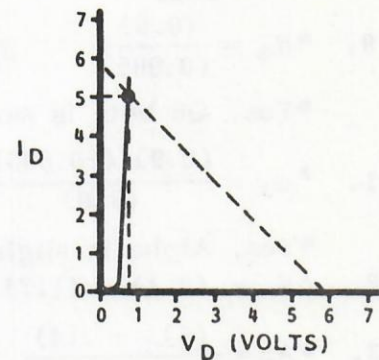
1. b forward; reverse
2. c A transistor amplifier circuit normally operates in the linear area.
3. d The current gain, Beta dc, is equal to I_C/I_B .
4. b The current gain, Alpha dc, is equal to I_C/I_E .
5. d Readings may be so close in value that no difference can be seen.
6. a increase; increase
7. b $M3-M2 = I_B$; $I_E-I_C=I_B$
8. d Any of the above.
9. a increase; increase
10. c linear area.
11. a cut-off area.
12. b decrease.
13. a 1.46; 0.973 $I_C = I_E - I_B = 1.5 - 0.04 = 1.46$
 $\alpha = I_C/I_E = 1.46/1.5 = 0.973$
14. d 132 $\beta_{dc} = \frac{I_C}{I_B} = \frac{I_E - I_B}{I_B} = \frac{2 - 0.015}{0.015} = 132.33$
15. d 6 $A_v = \frac{V_{out}}{V_{in}} = \frac{3}{0.5} = 6$

ANSWERS - J1 INFORMATION SHEET 2 / INFORMATION SHEET 3

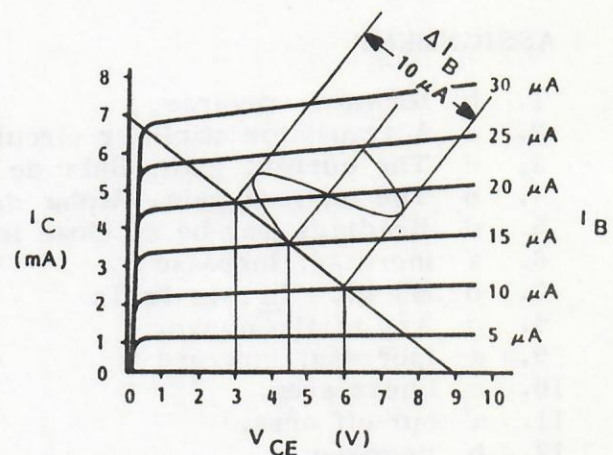
INFORMATION SHEET 2 - TRANSISTOR CHARACTERISTIC CURVES

ASSIGNMENT

1. X intercept = $V_C = \underline{6 \text{ V}}$
Y intercept = $V_C/R_D = 6/1 \text{ K} = \underline{6 \text{ mA}}$
2. $V_D \cong \underline{0.75 \text{ V}}$



3. X intercept = $+V = \underline{9 \text{ V}}$
Y intercept = $+V/R_C = 9/1.3 \text{ K} = \underline{0.0069 \text{ mA}}$
4. $I_C \cong \underline{3.7 \text{ mA}}$
 $V_{CE} \cong \underline{4.5 \text{ V}}$
5. $\Delta I_C \cong 4.7 - 2.5 = \underline{2.2 \text{ mA}}$
 $\Delta V_{CE} \cong 6 - 3 = \underline{3 \text{ V}}$



6. d If in the circuit of Figure 10(a), the operating point is shifted to $25 \mu\text{A}$, the result will be clipping.
7. a $A_v = V_{out} / V_{in} = 2.7/0.09 = \underline{30}$

INFORMATION SHEET 3 - TRANSISTOR MODELS

ASSIGNMENT

1. b $\underline{12.5 \Omega}$ $r'_e = 25/I_E \cong 25/I_C = 25/2 = \underline{12.5 \Omega}$
2. d $h_{ib} = r'_e$
3. a $\underline{250}$ $\beta_{dc} = I_C/I_B = 2/.008 = \underline{250}$
4. c $\underline{0.996}$ $\alpha = \beta / (1 + \beta) = 250/251 = \underline{0.996}$
5. b $\underline{176}$ $A_v = R_C/r'_e = 2200/12.5 = \underline{176}$

ANSWERS - J1 INFORMATION SHEET 3 (CONT)/ LESSON 3

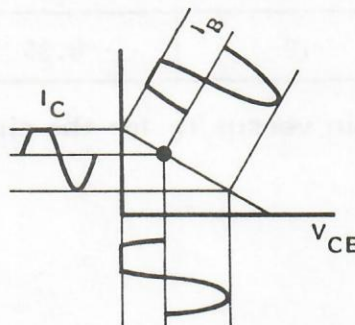
INFORMATION SHEET 3 - TRANSISTOR MODELS (CONT)

6. c The equivalent circuit shown in Figure 7 is an h-parameter model.
7. a Resistance R1 in Figure 7 represents h_i , the input resistance.
8. d Resistance R2 in Figure 7 represents h_o , the output admittance.
9. c Generator G1 in Figure 7 represents h_r , the Reverse Voltage Transfer.
10. a Generator G2 in Figure 7 represents I_{out} , which is βI_B or αI_E .
11. c Given the output admittance of the equivalent circuit in Figure 7 the output resistance can be found from $1/h_o$, the reciprocal of the output admittance.
12. The major drawback when using H-parameters is the complex calculations.

LESSON 3 - COMMON EMITTER TRANSISTOR AMPLIFIER GAIN

ASSIGNMENT

1. b The phase relationship between the input and output signals of a common emitter amplifier is 180° .
2. a 16.6Ω $r'e = 25/I_E = 25/1.5 = 16.6 \Omega$
3. c 123.2 $A_v = R_C/(25/I_E) = 1400/(25/2.2) = 1400/11.36 = 123.2$
4. b 80 $\beta_{dc} = I_C/I_B = 4/0.5 = 80$
5. d When the base bias is high the result is clipping of the output signal.



ANSWERS - J1 EXPERIMENT NO. 3

EXPERIMENT NO. 3 - COMMON EMITTER AMPLIFIER OPERATION

PROCEDURE

6. $V_{out\ ac} = \underline{1.35}$ V p-p
7. They are 180° out of phase.
8. $A_v = \underline{135}$
9. $A_v = \underline{160}$
11. A sine wave almost 1 cm p-p centered on 5 volts dc.
12. As I_B and I_C are reduced, the gain drops and the average dc level increases to approximately 7 volts. As I_B and I_C are increased, distortion occurs as the transistor moves into saturation and V_C moves close to zero volts (0.12 V).
13. As the input is increased, the top of the output sine wave starts to flatten and then the bottom flattens indicating saturation and cut-off.
14. $V_{in\ max} = \underline{56}$ mV p-p; $V_{max\ und.} = \underline{7}$ V p-p
- 15.

SET		DATA	
I_C (mA)	V_{in} (mV p-p)	V_{out} (V p-p)	A_v (measured)
4	10	1.35	135
3	10	1.05	105
2	10	0.7	70
1	10	0.35	35

TABLE 1 - Gain versus I_C for the circuit of Figure 2.

ANSWERS - J1 EXPERIMENT NO. 3 (CONT)

EXPERIMENT NO. 3 - COMMON EMITTER AMPLIFIER OPERATION (CONT)

18.

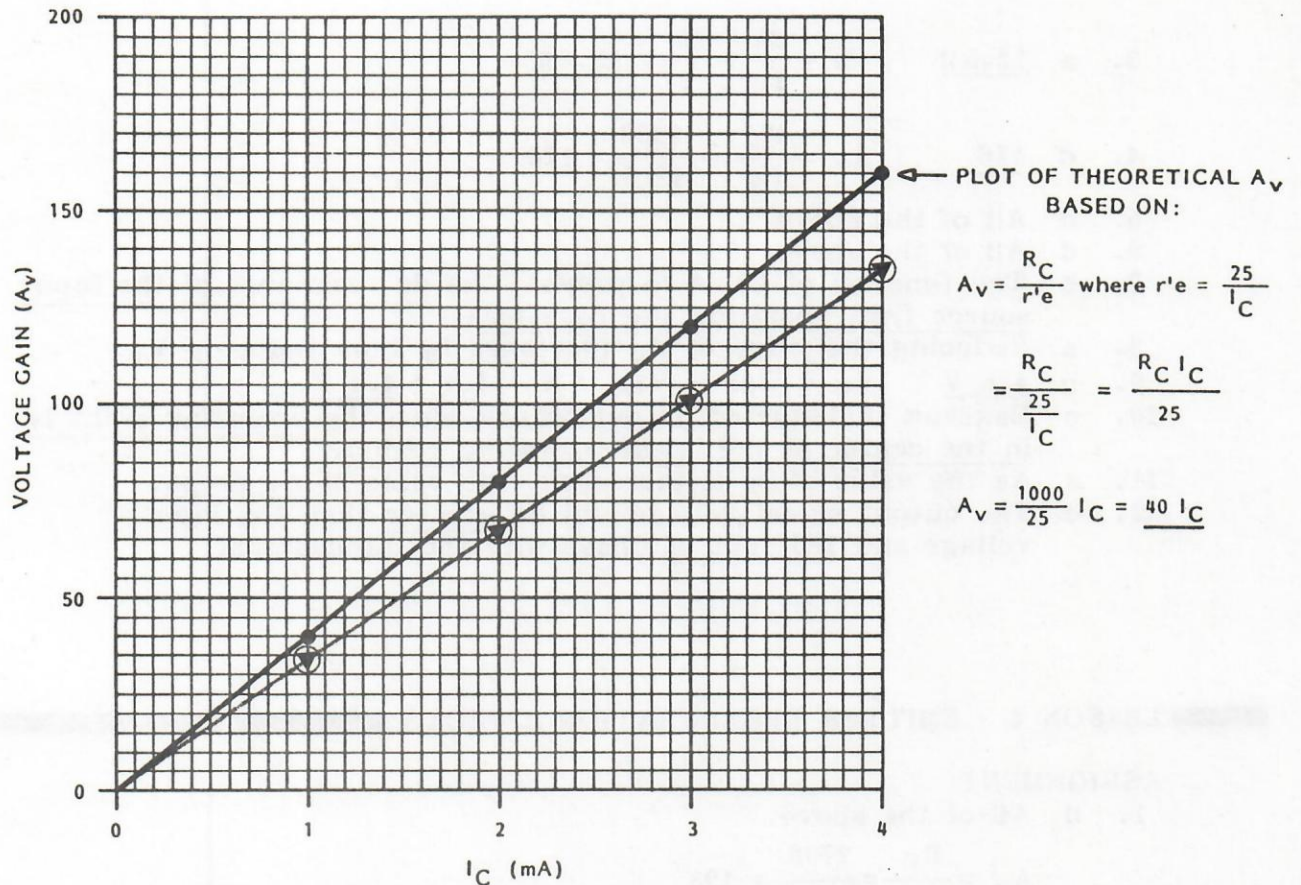


Figure 2 - Plot of theoretical and actual gain for different values of I_C .

20. $V_{out} = 2.4 \text{ V p-p}$

21. $A_v = \frac{(2.4)}{10 \text{ mV}} \quad A_v = \underline{240}$

22. $A_v = \underline{280}$

• The measured and theoretical gains are close.

• The measured gain with $R_C = 10\text{K}$ is higher than when $R_C = 1\text{K}$.

23. $V_{in \text{ max}} = \underline{16 \text{ mV p-p}}$

• The maximum allowable input signal is much lower when $R_C = 10\text{K}$ and A_v is high.

ASSIGNMENT

1. b emitter; input and output

2. a $\underline{2 \text{ mA}}$ $I_E = I_C = \frac{V_{RC}}{R_C} = \frac{4.4}{2200} = \underline{2 \text{ mA}}$

ANSWERS - J1 EXPERIMENT NO. 3 (CONT)/LESSON 4

EXPERIMENT NO. 3 - COMMON EMITTER AMPLIFIER OPERATION (CONT)

3. a 12.5 Ω $r'e = \frac{25}{I_E} = \frac{25}{2} = \underline{12.5 \Omega}$
4. d 176 $A_v = \frac{R_C}{r'e} = \frac{2200}{12.5} = \underline{176}$
5. d All of the above.
6. d All of the above.
7. b The function of C1 is to prevent the dc resistance of the input source from upsetting the base bias.
8. a Reducing the value of R_B increases I_B thus reducing V_C .
9. b 4.6 V $V_O = V_{CC} - V_{RC} = 9 - 4.4 = \underline{4.6 V}.$
10. c Maximum undistorted output occurs when the operating point is in the center of the linear operating region.
11. a As the value of I_E is increased, the value of $r'e$ drops.
12. c The output signal voltage will be greater than the input voltage and 180° out of phase with the input signal.

LESSON 4 - EMITTER DEGENERATION EFFECTS

ASSIGNMENT

1. d All of the above.

$$A_v = \frac{R_C}{r'e} = \frac{2700}{14} = \underline{193}$$

2. d All of the above.

3. c When selecting an operating point in a CE circuit that has a 1 volt drop across the emitter resistor and a V_{CC} of 15 volts, the ideal V_{CE} point operating point is 7 volts.

$$V_{CE \text{ IDEAL}} = \frac{V_{CC} - V_{RE}}{2} = \frac{15-1}{2} = \underline{7 V}$$

4. b Operating at the ideal Q point (V_{CE}) allows the maximum p-p output voltage swing.
5. a Moving away from the ideal operating point, in either direction, in a CE amplifier, causes output signal clipping.

ANSWERS J1 - EXPERIMENT NO. 4

EXPERIMENT NO. 4 - EMITTER DEGENERATION

PROCEDURE

4. $V_{out} = 1.4 \text{ V p-p}$
5. $A_v = \frac{1.4}{0.02} \quad A_v = 70$
6. $A_v = 80$
8. $V_{out} = 0.175 \text{ V p-p}$
 $A_v = \frac{0.175}{0.02} = 8.75$
9. $A_v = 8.89$
 $\bullet$ Yes, they are extremely close.
 $\bullet$ Yes, the gain with R_E is much lower than without it.
- 10.

SET		READ	CALCULATE
$I_C \text{ (mA)}$	$V_{in} \text{ p-p}$	$V_{out} \text{ p-p}$	$A_v = V_{out} / V_{in}$
2	20 mV	0.175	8.75
3	20 mV	0.18	9.00
4	20 mV	0.18	9.00
5	20 mV	0.185	9.25
6	20 mV	0.185	9.25

TABLE 1 - Gain versus I_C for the circuit of Figure 3 with the 100 ohm emitter resistor.

12. The gain varies very slightly, from 8.75 to 9.25.
15. $V_{out} = 7.5 \text{ V p-p}$
16. Rotation of the bias pot in one direction causes saturation. In the other direction, the output is clipped. In either direction there is distortion.

ASSIGNMENT

1. c The best collector operating point in a CE amplifier is close to the center of the linear region.
2. b 5 V $V_{RC} = (V_{CC}) - (V_C) = (9) - (4) = 5 \text{ V}$
3. c 5 mA $I_C = \frac{V_{RC}}{R_C} = \frac{5}{1000} = 0.005 \text{ A}$
4. a 0.5 V $V_{RE} = I_{RE} (R_E) = 0.005 (100) = 0.5 \text{ V}$
5. b 0.7 V $V_{BE} = V_B - V_E = (1.2) - (0.5) = 0.7 \text{ V}$

ANSWERS J1 - EXPERIMENT NO. 4 (CONT)/LESSON 5

EXPERIMENT NO. 4 - EMITTER DEGENERATION (CONT)

6. a 5 Ω $r'_e = \frac{25}{I_E}$ where $I_E \cong I_C = 5 \text{ mA}$ in (3) above.

$$r'_e = \frac{25}{5} = \underline{5 \Omega}$$

7. d 9.5 $A_v = \frac{R_C}{R_E + r'_e} = \frac{1000}{105} = \underline{9.5}$

8. b 50 μA $I_B = \frac{I_C}{\beta} = \frac{0.005}{100} = \underline{50 \mu\text{A}}$

9. a 29 mV $V_{in} = \frac{V_{out}}{A_v} = \frac{7.5}{90} = \underline{0.0833 \text{ V p-p}}$

10. d All of the above. $V_{in \text{ rms}} = (0.0833) \times (0.707) \times (0.5) - (0.029 \text{ V}) = \underline{29 \text{ mV}}$

LESSON 5 - BIASING CIRCUITS

ASSIGNMENT

1. a 333.3 K $R_B = \frac{V_{CC}}{I_B} = \frac{20}{60 \times 10^{-6}} = \underline{333.3 \text{ K}}$

2. c 13 mA $I_C = \beta I_B (175)(75 \times 10^{-6}) = \underline{0.013 \text{ A}}$

3. c The most stable bias configuration is voltage divider bias.

4. a Emitter bias is not used often because it requires two voltage sources.

5. b The voltage divider bias system is used most frequently because it is stable.

ANSWERS - J1 EXPERIMENT NO. 5

EXPERIMENT 5 - TRANSISTOR BIAS STABILITY

PROCEDURE

4.

CIRCUIT	1 NORMAL BIAS Q6 V_C	2 LOWER BETA Q6 V_C	3 NEW TRAN- SISTOR Q7 V_C	4 $V_{out\ ac}$ Q7	5 A_v Q7
A. BASE BIAS	4.5 V	6.7 V	6.3 V	1.8 V	18
B. COLLEC- TOR BIAS	4.5 V	5.8 V	5.4 V	1.75 V	17.5
C. VOLTAGE DIV. BIAS	4.5 V	4.6 V	4.6 V	1.85 V	18

TABLE 1 - Amplifier operating points and voltage gains.

5. •Yes, from 4.5 to 6.3V (Typical).
•No, they do not have identical beta values.
9. The operating point shift is smaller when Collector Feedback bias is used.
10. The shift in operating point is smaller when Collector Feedback bias is used.
11. Yes.
14. The bias shift is the least of all the bias circuits. The value of V_C shifts to 4.6 V. (Typical)
15. Barely any change.
19. $V_{out} = \underline{1.8}$ V p-p
20. • $A_v = \underline{18}$
•None.

ASSIGNMENT

1. a Base Bias.
2. a The circuit of Figure 5 is the most unstable of all the bias methods.

$$3. \quad b \quad \underline{166 \text{ K}} \quad R_B = \frac{V_{CC} - V_E}{I_B} = \frac{9 - 0.7}{50 \times 10^{-6}} = \underline{166,000}$$

$$4. \quad c \quad \underline{5.5 \text{ mA}} \quad I_C = \beta I_B = 110 \times 50 \times 10^{-6} = \underline{5.5 \text{ mA}}$$

$$5. \quad c \quad \underline{12.5 \Omega} \quad r'_e = \frac{25}{I_E} = \frac{25}{2} = \underline{12.5 \Omega}$$

$$6. \quad b \quad \underline{2250 \Omega} \quad V_{RC} = \frac{V_{CC}}{2} = \frac{9}{2} = 4.5 \text{ V} \quad R_C = \frac{V_{RC}}{I_C} = \frac{4.5}{0.002} = \underline{2250 \Omega}$$

ANSWERS - J1 EXPERIMENT NO. 5 (CONT)/ LESSON 6

EXPERIMENT 5 - TRANSISTOR BIAS STABILITY (CONT)

7. a 176 $A_v = \frac{R_C}{r'e} = \frac{2200}{\frac{25}{2}} = \frac{2200}{12.5} = \underline{176}$
8. d The circuit of Figure 6 uses Voltage Divider Bias.
9. b The circuit of Figure 6 is the most stable bias system.
10. c 1.7 V $V_{R2} = V_{R4} + V_{BE} = 1 + 0.7 = \underline{1.7V}$
11. d None of the above.
12. c The circuit of Figure 7 uses Emitter Bias.
13. d $I_E = \frac{V_{EE} - V_{BE}}{R3}$
14. a The circuit of Figure 7 is as stable as the circuit of Figure 6 the Voltage Divider Bias circuit.
15. c The normal voltage from base to ground in the emitter bias circuit is zero volts.
16. b The voltage gain for the emitter bias circuit in Figure 7 is $A_v = \underline{R2/R3}$.
17. b The circuit of Figure 8 uses Collector Feedback Bias.
18. a $(V_{CC} - V_{R2} - V_{BE})/R1$
19. d $R2/r'e$
20. c If, in the circuit of Figure 8, $+V_{CC}$ is changed to $-V_{CC}$, it is necessary to change Q1 to a PNP transistor.

LESSON 6 - VOLTAGE DIVIDER BIASING DESIGN

ASSIGNMENT

- a The most stable biasing system for the CE amplifier configuration is the voltage divider bias circuit.
- b When two resistors in series are placed in the emitter circuit and one of them is bypassed with a capacitor, the unbypassed resistor acts as the swamping resistor.
- b In a small signal CE amplifier, the emitter current is set at approximately 1 mA.
- c When calculating the component values of a CE amplifier circuit, the emitter voltage is made approximately equal to $V_{CC}/10$.
- a The value of the emitter resistance, R_E , for any CE amplifier may be determined from V_E/I_C .

ANSWERS - J1 EXPERIMENT NO. 6

EXPERIMENT NO. 6 - VOLTAGE DIVIDER BIASED AMPLIFIER

PROCEDURE

2. • A digital voltmeter was used for the answers below.

VOLTAGE	TEST POINTS	EXPECTED *	MEASURED
V_B	Base to Ground	1.8 V	1.77 V
V_E	Emitter to Ground	1.1 V	1.11 V
V_C	Collector to Ground	5.7 V	5.72 V
V_{CC}	+V2 to Ground	9 V	9.03 V
V_{BE}	Base to Emitter	0.7 V	0.66 V

* Calculated in Lesson J1-6

TABLE 1 - Voltage distribution for the circuit of Figure 1.

3. • Yes, V_{BE} falls between 0.6 and 0.7 volts.
 • $V_{BE} = (1.77) - (1.11)$
 $= 0.66 \text{ V}$
 • Yes, the calculated and measured values of V_{BE} are equal.
5. $V_{out} = 2.4 \text{ V p-p}$
6. • $A_v = \frac{(2.4)}{0.1} = 24$
 • Yes, it measures 24.
12. $V_{out} = 5.5 \text{ V p-p}$
13. Both the positive and negative output peaks are clipped as are the positive peaks of the input signal.
14. The output signal moves up on the crt screen and the positive peaks are clipped.
15. The output signal moves downward on the crt screen and the tips of the positive peaks of the input signal appear in the output waveform.

ANSWERS - J1 EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - VOLTAGE DIVIDER BIASED AMPLIFIER (CONT)

16.

NO.	FAULT	EFFECT ON VOLTAGES			
		V_E	V_B	V_C	AC COLLECTOR OUTPUT
1	No Fault	1.67	1.02	5	Normal
2	Shorted B-E	0.2	0.02	7.8	No output
3	Shorted C-E	1.7	2	2	No output
4	Shorted C1	0.02	0	8	No output
5	Shorted R_C	1.66	1	8	No output
6	Open R_C	0.7	0.13	0.15	No output
7	Open R1	0	0	7.99	No output
8	Open R2	1.99	2.6	2.6	Distorted Output
9	Open C1	1.67	1.02	5	No output
10	Open C2	1.67	1.02	5	Reduced Output

TABLE 2 - Troubleshooting chart.

17.

TEST MEASUREMENTS	FAULT DIAGNOSIS
V_B and $V_E = 0$ V	R1 circuit open or no V_{CC}
V_B and $V_E = 0.2$ V	Short from base to emitter
V_E and $V_C = 2$ V	Short from collector to emitter

TABLE 3 - Troubleshooting problems.

ANSWERS - J1 EXPERIMENT NO. 6 (CONT)

EXPERIMENT NO. 6 - VOLTAGE DIVIDER BIASED AMPLIFIER (CONT)

ASSIGNMENT

1. b 1.2 volts Emitter to ground voltage drop should be approximately 1/10 of V_{CC} .

$$V_E = \frac{V_{CC}}{10} = \frac{12}{10} = \underline{1.2 \text{ V}}$$
2. c 1000 Ω
$$R_E = \frac{V_E}{I_E} = \frac{1.2}{1 \times 10^{-3}} = 1200 - 200 = \underline{1,000 \Omega}$$
3. b 12 K $R_2 = (10) R_4 + R_5 = (10) 1200 \text{ K} = \underline{12 \text{ K}}$
4. c 1.5 volts $V_B = V_{BE} + V_E = 0.3 + 1.2 = \underline{1.5 \text{ V}}$
5. d 0.125 mA
$$I_{R_2} = \frac{V_B}{R_2} = \frac{1.5}{12,000} = \underline{0.125 \text{ mA}}$$
6. a 10.5 volts $V_{R_1} = V_{CC} - V_{R_2} = 12 - 1.5 = \underline{10.5 \text{ volts}}$
7. a 10 μA
$$I_B = \frac{I_C}{\beta} = \frac{1 \times 10^{-3}}{100} = \underline{10 \mu\text{A}}$$
8. c 5.4 volts
$$V_{R_3} = \frac{V_{CC} - V_E}{2} = \frac{12 - 1.2}{2} = \underline{5.4 \text{ volts}}$$
9. a 5.4 K
$$R_3 = \frac{V_{R_3}}{I_C} = \frac{5.4}{1 \times 10^{-3}} = \underline{5400 \Omega}$$
10. c 24
$$A_v = \frac{R_3}{R_4 + r'_e} = \frac{5400}{200 + 25} = \underline{24}$$
11. c 4.4
$$A_v = \frac{R_3}{R_4 + R_5 + r'_e} = \frac{5400}{200 + 1 \text{ K} + 25} = \underline{4.4}$$
12. a 216
$$A_v = \frac{R_C}{r'_e} = \frac{5400}{25} = \underline{216}$$
13. d All of the above.
14. a The gain of the circuit in Figure 5 can be increased by reducing the value of R_4 .

$$A_v = \frac{R_3}{R_4 + r'_e}$$
15. b Shifting the operating point of transistor Q1 in Figure 5 from its optimum setting will reduce the maximum undistorted output level.

ANSWERS - J1 LESSON 7/EXPERIMENT 7

LESSON 7 - INPUT/OUTPUT IMPEDANCES

ASSIGNMENT

1. c 100 mV $V_{in} = V_S \frac{R_{in}}{R_S + R_{in}} = (300 \text{ mV}) \frac{1 \text{ K}}{2 \text{ K} + 1 \text{ K}} = \underline{100 \text{ mV}}$
2. a The input resistance of an amplifier can be specified as Z_{in} .
3. d All of the above.
4. c 94 K $R_{in} = \beta R_E = 125 (750) = \underline{93,750 \Omega}$
5. a 16.6 K $Z_{in} = R1 // R2 // R_{in} = 50 \text{ K} / 3 = \underline{16.66 \text{ K}}$

EXPERIMENT NO. 7 - I-O IMPEDANCE MEASUREMENT

PROCEDURE

3. $V_B = \underline{2.05 \text{ V}}$
4. • $V_B = \underline{2.1 \text{ V}}$
• Barely; it drops V_B only 0.05 volts.
5. • $I_B = \underline{6 \mu A}$
• $R_{IN} = \frac{V_{IN}}{I_B} = \frac{(2)}{(6 \mu A)} \quad R_{IN} = \underline{333.33 \text{ K}}$
- Close; theoretical R_{IN} is 275 K while measured is 333 K (typical).
7. $V_{out} = \underline{0.46 \text{ V p-p}}$
8. $A_v = \frac{V_{out}}{V_{in}} = \frac{(0.46)}{0.02} \quad A_v = \underline{23}$
11. ☒ OHMMETER $Z_{in} = \underline{6.5 \text{ K}}$
12. • $Z_{in} = \underline{5.9 \text{ K}}$
• Yes, the measured R_{in} and the theoretical R_{IN} are close.
14. $V_{OUT} = \underline{0.4 \text{ V p-p}}$
15. $Z_{out} = (3300) \frac{(0.8) - (0.4)}{(0.4)} \quad Z_{out} = \underline{3.3 \text{ K}}$
16. $A_v = \frac{V_{out}}{V_{in}} = \frac{(0.2)}{0.04} \quad A_v = \underline{5}$
17. • $A_v = \underline{23}$
• Yes, the gain is less than 1/4 that in step 8.

ANSWERS - J1 EXPERIMENT NO. 7 (CONT) / EXPERIMENT NO. 8

EXPERIMENT NO. 7 - I-O IMPEDANCE MEASUREMENT (CONT)

ASSIGNMENT

1. b 315 K $R_{IN} = \beta R_E = 150 (2000 + 100) = \underline{315 K}$
2. b 18.75 K $R_{in} = \beta(r'e + R_D) = 150 (25 + 100) = \underline{18.75 K}$
3. c 8.02 K $Z_{in} = R_1 // R_2 // R_{in} = 47 K // 20 K // 18.75 K = \underline{8.02 K}$
4. d 0.2 V $V_{in} = (V_{NL}) \frac{Z_{in}}{R_S + Z_{in}} = (0.3) \frac{10}{5 + 10} = \underline{0.2 V}$
5. c 47 $A_v = \frac{R_C}{R_D} = \frac{4,700}{100} = \underline{47}$
6. a 2.2 $A_v = \frac{R_C}{R_D + R_E} = \frac{4700}{100 + 2000} = \underline{2.2}$
7. d 2.75 $V_{R2} = V_{BE} + V_E$ where $V_E = I_E (R_D + R_E)$
 $= V_{BE} + I_E (R_D + R_E) = 0.65 + 0.001 (2100)$
 $V_{R2} = \underline{2.75 V}$
8. b 15 $R_{L \text{ effective}} = 4.7 K // 2.2 K = \frac{(4.7)(2.2)}{4.7 + 2.2} = 1.5 K$
 $A_v = \frac{R_{L \text{ effective}}}{R_D} = \frac{1,500}{100} = \underline{15}$
9. c 3V $V_{in} = (0.3) \frac{10 K}{5K + 10 K} = 0.2 V \text{ (as in Q4)}$
 $A_v = 15 \text{ (as in Q8)}$
 $V_{out} = V_{in} A_v = (0.2)(15) = \underline{3 V}$
10. d All of the above.

EXPERIMENT NO. 8 - CHARACTERISTIC CURVES

PROCEDURE

3. TABLE 1 CURVE A $I_B = 20 \mu A$

$V_{CE} (V)$ SA DOWN	$V_{RC} (mV)$ SA UP	$I_C (mA)$	$V_{CE} (V)$ SA DOWN	$V_{RC} (mV)$ SA UP	$I_C \text{ mA}$
8	310	3.1	0.3	275	2.75
6	306	3.06	0.2	188	1.88
3	297	2.97	0.1	25	0.25
1	288	2.88	0*	2	0.02

*As close to zero as possible.

TABLE 1 - I_C versus V_{CE} for $I_B = 20 \mu A$.

ANSWERS - J1 EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - CHARACTERISTIC CURVES (CONT)

5. TABLE 2 CURVE B $I_B = 30 \mu A$

V_{CE} (V) SA DOWN	V_{RC} (mV) SA UP	I_C (mA)	V_{CE} (V) SA DOWN	V_{RC} (mV) SA UP	I_C mA
8	530	5.3	0.3	444	4.44
6	519	5.19	0.2	280	2.80
3	498	4.98	0.1	44	0.44
1	482	4.82	0*	3	0.03

*As close to zero as possible.

TABLE 2 - I_C versus V_{CE} for $I_B = 30 \mu A$.

7.

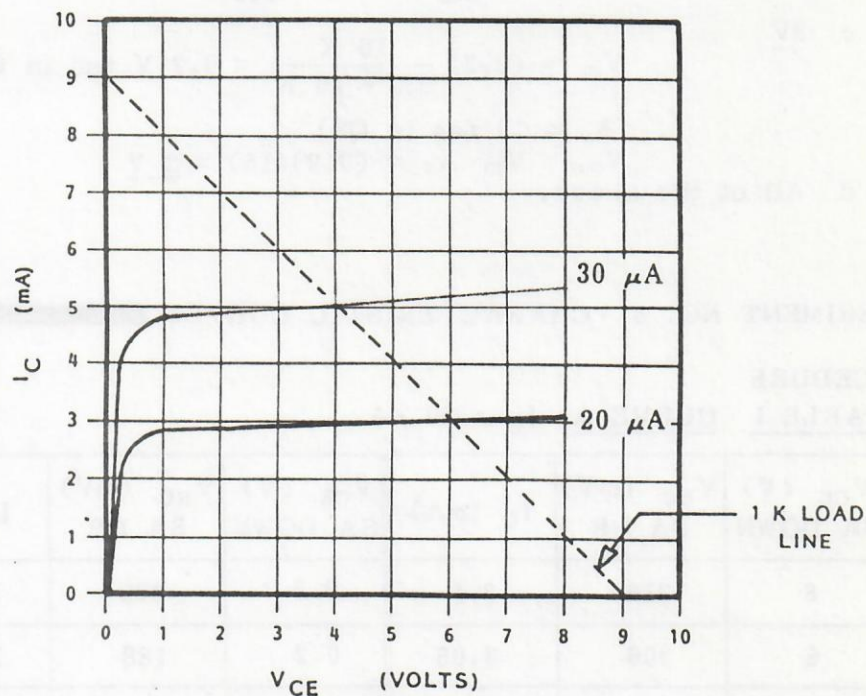


Figure 2 - Graph plot of V_{CE} versus I_C for $I_B = 20 \mu A$, and $30 \mu A$.

ANSWERS - J1 EXPERIMENT NO. 8 (CONT)

EXPERIMENT NO. 8 - CHARACTERISTIC CURVES (CONT)

8. $I_B = 20 \mu A$; $V_{CE} = 3 V$ $\beta_{dc} = \frac{(2.97)}{(0.02)} = \underline{148.5}$

$I_B = 30 \mu A$; $V_{CE} = 3 V$ $\beta_{dc} = \frac{(4.98)}{(0.03)} = \underline{166}$

9. $\beta_{ac} = \frac{(4.98) - (2.97)}{(30 \mu A) - (20 \mu A)} = \frac{(2.01)}{(0.01)} = \underline{201}$

13. MEASURED $V_{CE} = \underline{3.98 V}$
 GRAPH
 (FIGURE 2) $V_{CE} = \underline{3.9 V}$

*Very close; within 0.08 volts.

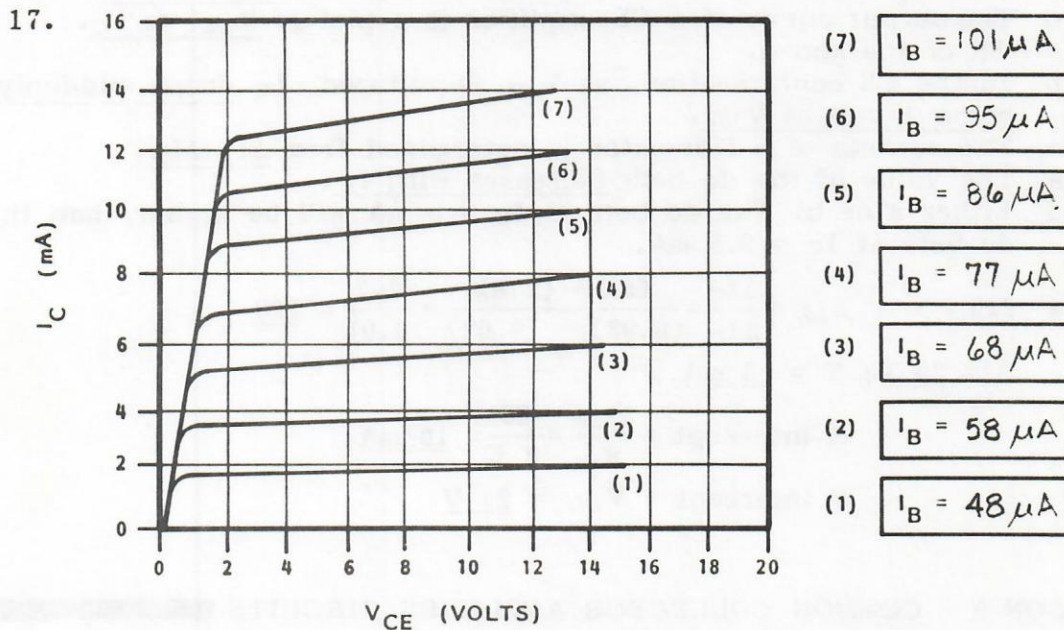


Figure 4 - Set of characteristic curves; EXPERIMENT.

18. $\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} = \frac{(I_{C7}) - (I_{C1})}{(I_{B7}) - (I_{B1})} = \frac{(13) - (1.8)}{(101) - (48)} = \frac{(11.2)}{(0.053)} = \underline{211.3} \text{ (Typical)}$

ANSWERS - J1 EXPERIMENT NO. 8 (CONT)/LESSON 9

EXPERIMENT NO. 8 - CHARACTERISTIC CURVES (CONT)

22. ●As the input signal level is increased, the upper curve moves higher on the screen but the lower curve remains fixed.
●The lower curve rises on the display indicating an increased I_B . The upper curve maintains the same distance from the lower curve because the square wave level is unchanged.
23. ●X intercept = 15 V
Y intercept = 15 mA
●Yes.
24. ●It is vertical indicating that $R_C = 0$ ohms.
●As R_C is increased, the slope of the load line decreases. At 1 K the intercepts are again 15 volts and 15 mA.

ASSIGNMENT

1. c In the CE configuration the input is connected to the base and the output is taken from the collector.
2. a The input curve of a CE amplifier is a plot of V_{BE} vs I_B .
3. d The output curve of a CE amplifier is a plot of V_{CE} vs I_C .
4. d All of the above.
5. b In the CE configuration, as V_{CE} is reduced, I_C drops suddenly below 1 volt of V_{CE} .
6. c The ac beta of a transistor is determined from $\Delta I_C / \Delta I_B$.
7. a The value of the dc beta increases with I_C .
8. d Either a or b. The dc beta at $I_C = 5$ mA will be higher than the dc beta at $I_C = 2.8$ mA.
9. a 220 $\beta_{ac} = \frac{\Delta I_C}{\Delta I_B} = \frac{(5) - (2.8)}{(0.03) - (0.02)} = \frac{2.2}{0.01} = \underline{220}$
10. c X = 20 V; Y = 10 mA
$$X \text{ intercept} = \frac{V_{CC}}{R_C} = \frac{20}{2 \text{ K}} = \underline{10 \text{ mA}}$$
$$Y \text{ intercept} = V_{CC} = \underline{20 \text{ V}}$$

LESSON 9 - COMMON COLLECTOR AMPLIFIER CIRCUITS

ASSIGNMENT

1. b The input resistance of a CC amplifier is the same as a CE.
($R_{in} = \beta R_E$)
2. a The phase difference between the input and output signals of a CC amplifier is 0° .
3. a The output impedance of a CC amplifier is very low.
4. d None of the above. a. R_{out} is low not high. b. Current gain is high ($\beta \times \beta$). c. Voltage gain is low, less than 1.
5. a The darlington amplifier circuit is most useful when it is being driven by a high impedance signal source.

ANSWERS - J1 EXPERIMENT NO. 9

EXPERIMENT NO. 9 - COMMON COLLECTOR AMPLIFIER OPERATION

PROCEDURE

2. •40 mV p-p.
•Exactly the same, 40 mV.
4. • $V_{in} = 2.7$ V p-p.
• $V_{out} = 2.65$ V p-p.
•Yes, 2.65 volts compared to 40 mV, measured in step 2, without the CC amplifier.
• V_{in} drops but only to 2.7 volts.
5. They are both in phase with each other.
6. $A_v = \frac{2.65}{2.7} = 0.98$
7. The calculated loaded input is 2.6 v p-p and the measured loaded input is 2.65 v p-p.
10. • $V_{in} = 3.8$ V p-p $V_{out} = 3.65$ V p-p
•The output voltage is higher.
11. $A_v = \frac{V_{in}}{V_{out}} = \frac{(3.8)}{(3.65)} = 0.96$
15. •22.5K
•The measured and calculated values of Z_{in} are reasonably close.
17. $V_{NL} = 4$ V p-p
18. $V_L = 2.5$ V p-p
19. $Z_{out} = 100 \frac{4 - (2.5)}{(2.5)} = 60 \Omega$
20. 58 Ω
22. There is no distortion in the output signal.
23. At maximum input there is some overdrive. The negative output peaks are clipped.
26. $V_E = 3.7$ volts ; $V_{BE} = 0.678$ volts
27. • V_{BE} increases to -1.6 volts (reverse biased) thus clipping the negative portion of the input signal.
• V_E increases to +5.94 volts due to the output coupling capacitor acting as an emitter bypass capacitor through the 100 ohm load. The capacitor charges to the peak positive signal and tends to reverse bias the BE junction.
•The output waveform consists of only the positive peaks.
28. The maximum allowable input signal before distortion occurs is 1.2 volts p-p.

ANSWERS - J1 EXPERIMENT NO. 9 (CONT)

EXPERIMENT NO. 9 - COMMON COLLECTOR AMPLIFIER OPERATION (CONT)

29.

NO.	FAULT	EFFECT ON VOLTAGES			
		V _B	V _E	V _C	AC EMITTER OUTPUT
1	No Fault	4.41	3.74	9	Normal, 2 V p-p
2	Shorted B-E	0.75	0.75	9	Output drops to 1 V p-p
3	Shorted C-E	4.49	9.0	9	No output signal
4	Shorted C1	1.53	0.9	9	Output distorts on neg. peak
5	Shorted R _E	0.65	0.1	9	No output
6	Open R _E	4.49	4.39	9	Low level distorted output
7	Open R1	0.00	0.12	9	Positive output peaks only
8	Open R2	8.51	7.81	9	Clipped positive peaks
9	Open Collector*	1.5	0.76	9	Output drops to 1 V p-p

*Measure collector voltage from loose end of removed wire lead because this is how an open collector is simulated.

TABLE 1 - Data for faults in the circuit of Figure 6.

ASSIGNMENT

- d The circuit shown in Figure 7 is called either an emitter follower or a common collector.
- c $\frac{200 \text{ K}}{Z_{in}} = \beta(R_E) = (100)(2000) = \underline{200 \text{ K}}$
- b $\underline{2 \text{ V}} \quad V_{in} = V_S \frac{Z_{in}}{Z_{in} + R_S} = (3) \frac{200}{200 + 100} = \underline{2 \text{ V}}$

ANSWERS - J1 EXPERIMENT NO. 9 (CONT)/LESSON 10

EXPERIMENT NO. 9 - COMMON COLLECTOR AMPLIFIER OPERATION (CONT)

4. a 1 K $Z_{out} = r'e \frac{R_s}{\beta}$ Ignoring $r'e$, we have:
- $$Z_{out} = \frac{R_s}{\beta} = \frac{100 \text{ K}}{100} = \underline{1 \text{ K}}$$
5. a When R_s is increased and beta remains the same, Z_{out} must increase because:
- $$Z_{out} = \frac{R_s}{\beta}$$
6. c The voltage gain of any common collector is slightly less than 1.
7. a 100 The current gain is approximately equal to beta or slightly less.
8. d 100 $A_p = A_i A_v = 100 (1) = \underline{100}$
9. d 31.5 K $Z_{in} = R1 // R2 // \beta(R3)$
 $= 75 \text{ K} // 75 \text{ K} // 200 (1000) = 75 // 75 // 200$
 $Z_{in} = \underline{31.5 \text{ K}}$
10. d All of the above.
11. b 150 Ω $Z_{out} = r'e \frac{R_s}{\beta} = \frac{30,000}{200} = \underline{150 \Omega}$ (neglecting $r'e$)
12. c The circuit shown in Figure 9 is called a Darlington Pair.
13. a 10,000 Darlington Pair Beta = $\beta_{Q1} \times \beta_{Q2} = (200)(50) = \underline{10,000}$
14. a 1 megohm $R_{in} = (\beta_{Q1})(\beta_{Q2})(R_E) = (200)(50)(100) = \underline{1 \text{ megohm}}$
15. c The voltage gain for the Darlington circuit in Figure 9 is slightly less than that for the emitter follower due to the loss suffered in $r'e$ Q1 and $r'e$ Q2.

LESSON 10 - COMMON BASE AMPLIFIER CIRCUITS

ASSIGNMENT

- a In the common base amplifier circuit, the element that is ac ground potential is the base.
- b In the common base amplifier circuit, the input impedance is low and the output impedance is high.
- d In the common base amplifier circuit, the voltage gain is high and the current gain is low.
- b In the common base amplifier circuit, the input signal and the output signal are in phase.
- d The major drawback of the common base circuit is its low input impedance.

ANSWERS - J1 EXPERIMENT NO. 10

EXPERIMENT NO. 10 - COMMON BASE AMPLIFIER OPERATION

PROCEDURE

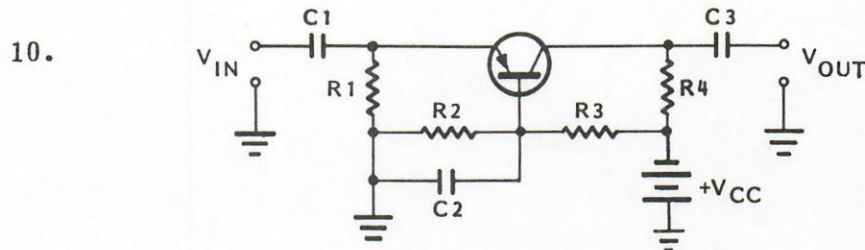
3. $V_{out} = 3.0 \text{ V p-p}$
4. They are the same; 0° .
5. $A_v = \frac{V_{out}}{V_{in}} = \frac{(3)}{0.02} = 150$
6. $r'_e = \frac{R_C}{A_v} = \frac{3300}{(150)} \quad Z_{in} = 22 \Omega$
8. $V_{NL} = 0.110 \text{ V p-p}$
9. $\bullet Z_{in} = (0.02) \frac{100}{(0.11) - (0.02)} = 22.2 \Omega$
 $\bullet$ Yes
 $\bullet$ Yes
11. $V_{FL} = 2 \text{ V}$
12. $\bullet R_{out} = (3300) \frac{(4) - (2)}{(2)} = 3300 \Omega$
 $\bullet$ Yes
13. They are in phase.

ASSIGNMENT

1. a The circuit shown in Figure 2 is defined as CB.
2. b 2 K $R_1 = \frac{V_{EE}}{I_E} \cong \frac{V_{EE}}{I_C} = \frac{3}{1.5 \times 10^{-3}} = 2 \text{ K}$
3. a 17 Ω $Z_{in} = r'_e // R_1 \cong r'_e = \frac{25}{I_C} = \frac{25}{1.5} = 16.666 \Omega$
4. d The output impedance in the circuit of Figure 2 is equal to R2.
5. c 194 $A_v = \frac{R_C}{r'_e} = \frac{3300}{17} = 194$
6. d All of the above.
7. a Common base circuits are used where low level high frequency signals are to be amplified.
8. c The current gain of the CB configuration is called alpha and is equal to I_C/I_E .
9. b The major disadvantage of the CB amplifier is its low input impedance.

ANSWERS - J1 EXPERIMENT NO. 10 (CONT)/INFORMATION SHEET 4

EXPERIMENT NO. 10 - COMMON BASE AMPLIFIER OPERATION (CONT)



INFORMATION SHEET 4 - TRANSISTOR SPECIFICATION SHEETS

ASSIGNMENT

1. d The transistor rating, NF, Noise Figure, does not have a diode equivalent.
2. c The maximum power dissipation, P_D , is a rating of the heat developed in the collector-base junction.
3. b The conductivity of a transistor is indicated by the rating, $V_{CE\ sat}$.
4. d All of the above.
5. a 475 mW Derated $P_D = P_D - (5\text{ mW} \times 30 - 25)$
 $= 500 - (5 \times 5) = 500 - 25 = \underline{475\text{ mW}}$
6. d The breakdown voltage between the base and the collector with the emitter open, is indicated by $V_{BR\ CBO}$.
7. a Transistor gain data is normally measured at 1 kHz.
8. c 2.73 mHz $f_\beta = f_T / \beta = 300\text{ mHz} / 110 = \underline{2.73\text{ mHz}}$
9. b 360 mHz $f_\alpha = f_T (1.2) = 300\text{ mHz} (1.2) = \underline{360\text{ mHz}}$
10. c 462.5 mHz $f_T = f_\beta (\beta) = 3.7 (125) = \underline{462.5\text{ mHz}}$
11. c 250 $h_{fe\ average} = \frac{MIN + MAX}{2} = \frac{100 + 400}{2} = \underline{250}$
12. a 50 From the spec sheet.
13. c f_T , 250 f_T is the GBP.
14. d 1.2 mHz $f_\beta = \frac{f_T}{\beta_{av}} = \frac{300\text{ mHz}}{\left(\frac{100 + 400}{2}\right)} = \frac{300}{250} = \underline{1.2\text{ mHz}}$
15. b 590 mW Derated $P_D = 625 - (5^\circ) (32 - 25) = \underline{590\text{ mW}}$

ANSWERS - II EXPERIMENT NO. 10 - COMMON BASE AMPLIFIER (CONT.)
 EXPERIMENT NO. 10 - COMMON BASE AMPLIFIER (CONT.)



EXPERIMENT NO. 10 - COMMON BASE AMPLIFIER (CONT.)

1. The common base amplifier has a voltage gain of approximately 1.
2. The common base amplifier has a voltage gain of approximately 1.
3. The common base amplifier has a voltage gain of approximately 1.
4. The common base amplifier has a voltage gain of approximately 1.
5. The common base amplifier has a voltage gain of approximately 1.
6. The common base amplifier has a voltage gain of approximately 1.
7. The common base amplifier has a voltage gain of approximately 1.
8. The common base amplifier has a voltage gain of approximately 1.
9. The common base amplifier has a voltage gain of approximately 1.
10. The common base amplifier has a voltage gain of approximately 1.
11. The common base amplifier has a voltage gain of approximately 1.
12. The common base amplifier has a voltage gain of approximately 1.
13. The common base amplifier has a voltage gain of approximately 1.
14. The common base amplifier has a voltage gain of approximately 1.
15. The common base amplifier has a voltage gain of approximately 1.

Unit Test
Transistors and Circuits
Part J1

Unit Test
Transistors and Circuits
Part II

Unit Test

Part J1 — Transistors and Circuits

Answer the following multiple choice questions.

1. When a PN junction is formed, electrons:
 - a. move from the N to P areas.
 - b. fill some holes in the P area.
 - c. by moving, create a barrier potential.
 - d. all of the above.
2. The barrier potential developed across a silicon PN junction is approximately:
 - a. 0.7 volts.
 - b. 0.485 volts.
 - c. 0.3 volts.
 - d. any of the above.
3. When a transistor is used as an amplifier, the B-E junction is _____ biased and the B-C junction is _____ biased.
 - a. forward; forward
 - b. forward; reverse
 - c. reverse; forward
 - d. reverse; reverse
4. A transistor labelled 2N2102A is indicated to be:
 - a. a two junction device.
 - b. the second version of the transistor.
 - c. type 2102.
 - d. all of the above.
5. When an analog ohmmeter is connected across the B-E junction of a transistor and reads 250 K, it indicates that the junction is:
 - a. reverse biased.
 - b. forward biased.
 - c. shorted.
 - d. none of the above.
6. A transistor amplifier circuit normally operates in the:
 - a. cut-off region.
 - b. saturation region.
 - c. linear region.
 - d. none of the above.

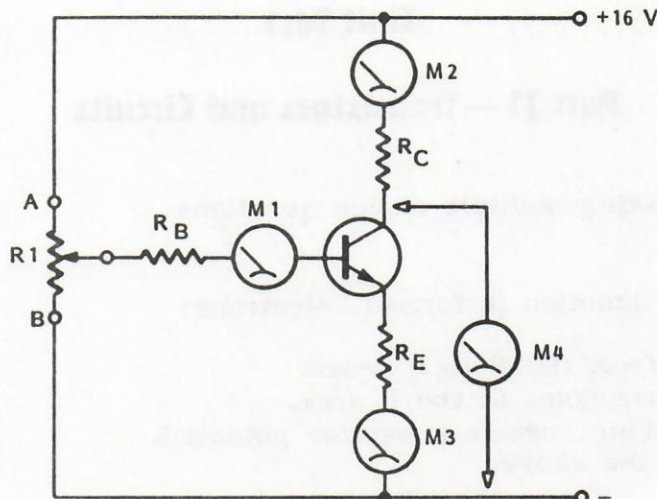


Figure 1 above refers to questions 7 to 10.

7. In the circuit of Figure 1, moving the arm of R_1 toward end A will cause the reading on M1 to _____ and the reading on M2 to _____.
 - a. increase; increase.
 - b. increase; decrease.
 - c. decrease; decrease.
 - d. decrease; increase.
8. If meters M2 and M3, in Figure 1 were accurate enough, the $M3 - M2$ reading would be equal to:
 - a. I_C .
 - b. I_B .
 - c. I_E .
 - d. I_{SOURCE} .
9. When R_1 in Figure 1 is adjusted so that meter M4 reads approximately 8 volts, the transistor is operating in the:
 - a. cut-off area.
 - b. saturation area.
 - c. linear area.
 - d. none of the above.
10. In Figure 1, given a base current of $50 \mu A$ and an emitter current of 2 mA, the collector current will be _____ mA and the transistor alpha is _____.
 - a. 2.05; 1.025
 - b. 1.95; 0.975
 - c. 1.95; 39
 - d. none of the above

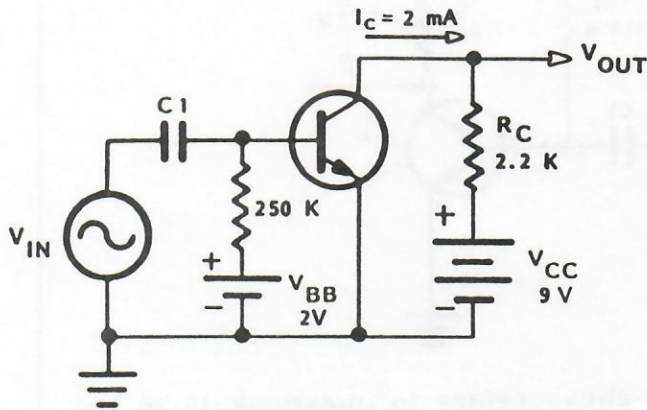


Figure 2 above refers to questions 11 to 14.

11. For the circuit shown in Figure 2, the value of r'_e is approximately:
 - a. 25 ohms.
 - b. 12.5 ohms.
 - c. 2.2 ohms.
 - d. 2 ohms.
12. The value of r'_e in Figure 2 is the same as:
 - a. h_{fe} .
 - b. h_{ie} .
 - c. R_{in} .
 - d. h_{ib} .
13. The circuit shown in Figure 2 has a voltage gain of:
 - a. 2200.
 - b. 176.
 - c. 113.
 - d. 13.5.
14. The phase relationship between the input and output signals of the amplifier shown in Figure 2 is:
 - a. zero degrees.
 - b. 180 degrees.
 - c. 360 degrees.
 - d. variable with r'_e .

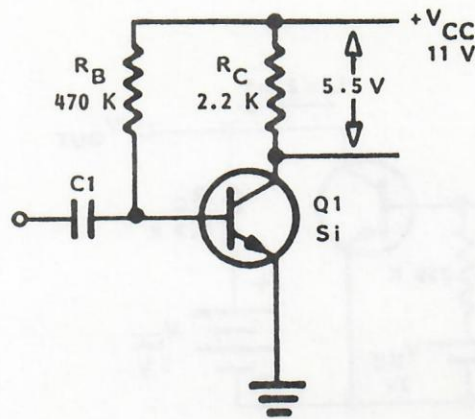


Figure 3 above refers to questions 15 to 19.

15. In the circuit of Figure 3, the emitter current, neglecting I_B , is approximately:
 - a. 2.5 mA.
 - b. 23.4 μ A.
 - c. 5 mA.
 - d. 23.4 mA.
16. The value of base current in the circuit of Figure 3:
 - a. is set by the value of R_B .
 - b. determines the voltage drop across R_C .
 - c. determines the voltage from collector to emitter.
 - d. all of the above.
17. The base current of Q1 in Figure 3 is closest to:
 - a. 2.5 mA.
 - b. 2.2 mA.
 - c. 11 μ A.
 - d. 22 μ A.
18. Given a voltage drop of 5.5 volts across R_C in Figure 3, the collector to emitter voltage is:
 - a. 4.4 V.
 - b. 4.6 V.
 - c. 5.5 V.
 - d. 11 V.
19. The maximum undistorted output voltage for Figure 3 can be achieved when the:
 - a. value of r'_e is kept high.
 - b. value of R_C is low.
 - c. operating point is in the center of the linear operating region.
 - d. operating point is in the saturation region.

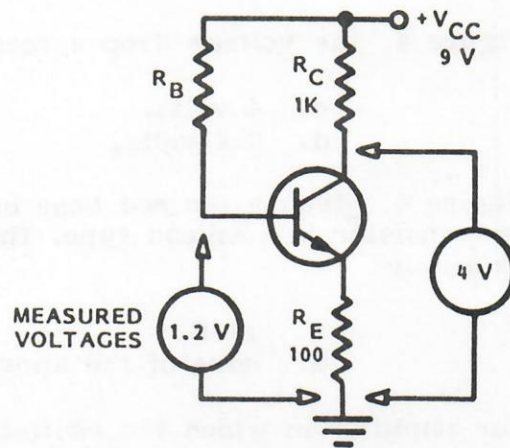


Figure 4 above refers to questions 20 to 27.

20. The addition of resistance in the emitter circuit, R_E in Figure 4, causes the circuit gain to:
 - a. drop.
 - b. be stabilized against changes in I_C .
 - c. be stabilized against changes in temperature.
 - d. all of the above.
21. For the circuit of Figure 4, the voltage drop across R_C is:
 - a. 4 volts.
 - b. 5 volts.
 - c. 9 volts.
 - d. insufficient data.
22. For the circuit of Figure 4, the collector current is:
 - a. 2 mA.
 - b. 4 mA.
 - c. 5 mA.
 - d. 9 mA.
23. For the circuit of Figure 4, the base-emitter voltage is:
 - a. 0.3 volts.
 - b. 0.7 volts.
 - c. 1.2 volts.
 - d. 0.4 volts.
24. If the beta of the transistor in Figure 4 is 100, the base current flowing through R_B is:
 - a. 5 μA .
 - b. 50 μA .
 - c. 5 mA.
 - d. none of the above.
25. If the circuit of Figure 4 has a voltage gain of 90 and the maximum allowable collector voltage swing is 7.5 volts peak-to-peak, the maximum allowable rms input signal is:
 - a. 29 mV.
 - b. 0.833 volts.
 - c. 0.0833 volts.
 - d. none of the above.

26. For the circuit of Figure 4, the voltage drop across R_E is:
- a. 0.5 volts.
 - b. 5 volts.
 - c. 4 volts.
 - d. 0.4 volts.
27. For the circuit of Figure 4, given a desired base current of $50 \mu A$, and that the transistor is a silicon type, the value of R_B should be approximately:
- a. 10K.
 - b. $10K + (\beta R_E)$
 - c. 156K.
 - d. none of the above.
28. Given a CE transistor amplifier in which the emitter is directly grounded, r_e equals 14 ohms and R_C is 2.7K, the gain:
- a. will vary with temperature.
 - b. is 193, theoretically.
 - c. will vary with I_E .
 - d. all of the above.
29. When selecting an operating point in a CE amplifier circuit that has a 1 volt drop across the emitter resistor and a V_{CC} of 15 volts, the ideal V_{CE} operating point is:
- a. 15 volts.
 - b. 14 volts.
 - c. 7 volts.
 - d. 1 volt.
30. The most stable bias circuit configuration is:
- a. base bias.
 - b. collector feedback bias.
 - c. voltage divider bias.
 - d. none of the above.
31. Emitter bias is not used often because it:
- a. requires 2 voltage sources.
 - b. is unstable.
 - c. is a complex circuit
 - d. all of the above.
32. Given a base current of $50 \mu A$ and a beta of 110 for a CE circuit, I_C is closest to:
- a. 160 mA.
 - b. 110 mA.
 - c. 5.5 mA.
 - d. 2.2 mA.

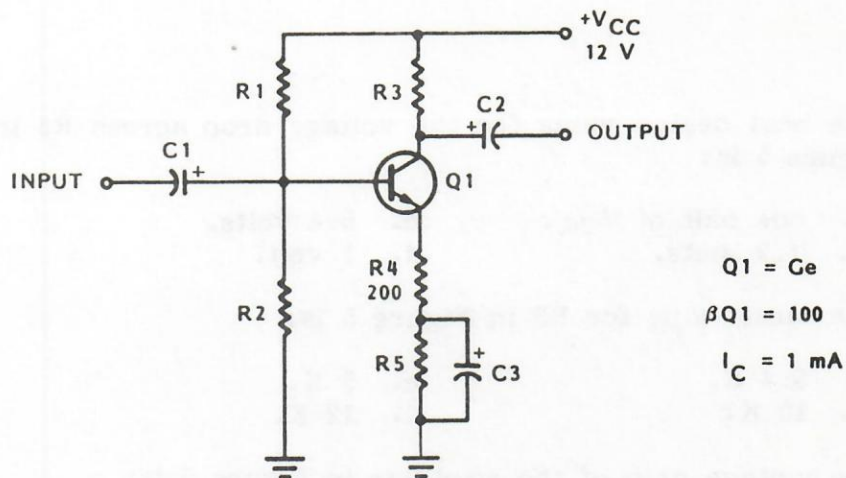


Figure 5 above refers to questions 33 to 44.

33. The voltage from emitter to ground in Figure 5 should be as close as possible to:
- 1 volt.
 - 1.2 volts.
 - 2 volts.
 - 12 volts.
34. The value of R5 in Figure 5 should be:
- 100 ohms.
 - 120 ohms.
 - 1000 ohms.
 - 1200 ohms.
35. The value of R2 in Figure 5 should be closest to:
- 100 K.
 - 12 K.
 - 2 K.
 - 1 K.
36. If Q1 in Figure 5 is germanium, the voltage drop across R2 is closest to:
- 1.9 volts.
 - 1.7 volt.
 - 1.5 volts.
 - 1.3 volts.
37. The current flow through R2 in Figure 5 is closest to:
- 0.1 mA.
 - 1 mA.
 - 1.25 mA.
 - 0.125 mA.
38. The voltage drop across R1 in Figure 5 is:
- 10.5 volts.
 - 11.0 volts.
 - 11.5 volts.
 - 12 volts.

39. The best design value for the voltage drop across R3 in Figure 5 is:
- a. one half of V_{CC} .
 - b. 1.2 volts.
 - c. 5.4 volts.
 - d. 1 volt.
40. The ideal value for R3 in Figure 5 is:
- a. 5.4 K.
 - b. 10 K.
 - c. 5 K.
 - d. 12 K.
41. The voltage gain of the amplifier in Figure 5 is:
- a. 4.
 - b. 3.
 - c. 24.
 - d. 44.
42. The voltage gain, for the circuit in Figure 5, when C3 is removed, will change to:
- a. 216
 - b. 10.
 - c. 4.4
 - d. remain unchanged.
43. If capacitor C3 were disconnected from the junction of R4 and R5, in Figure 5, and connected to the emitter, the gain would:
- a. increase to 216.
 - b. increase to 100.
 - c. remain the same.
 - d. decrease.
44. To overdrive the circuit of Figure 5 means that:
- a. too much input signal voltage is being applied.
 - b. the output signal may be driven into saturation.
 - c. the output signal may be driven into cut-off.
 - d. all of the above.

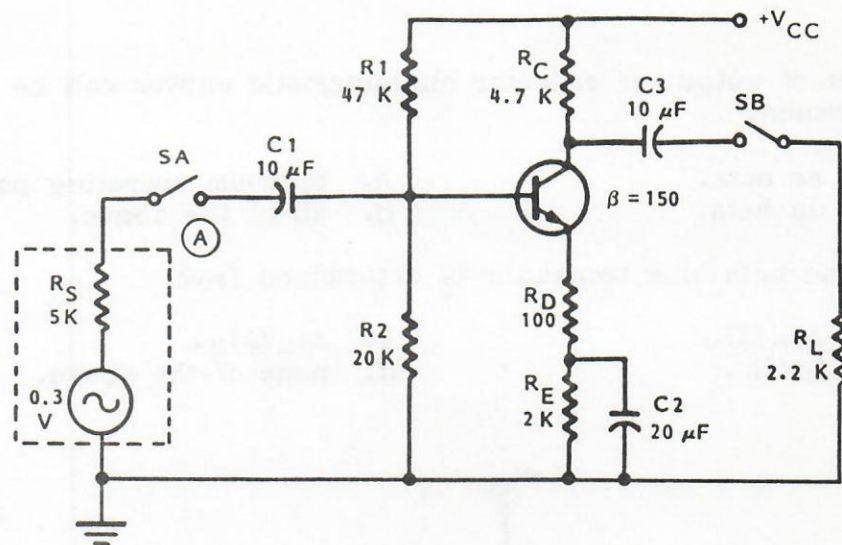


Figure 6 above refers to questions 45 to 49.

45. The ac input impedance of the transistor base circuit in Figure 6 (neglecting the parallel effects of R_1 and R_2), given that r'_e is 25 ohms, is approximately:
 - a. 315 K.
 - b. 18.75 K.
 - c. 2,125 ohms.
 - d. none of the above.
46. The input impedance, Z_{in} , as seen by the input generator is approximately:
 - a. 47 K.
 - b. 20 K.
 - c. 8 K.
 - d. 2.1 K.
47. Given a input impedance of 10 K at point A in Figure 6 and an unloaded source voltage of 0.3 volts, the signal voltage at point A, when switch S_A is closed, will be approximately:
 - a. 0.3 volts.
 - b. 0.15 volts.
 - c. 0.1 volts.
 - d. 0.2 volts.
48. The theoretical unloaded gain of the amplifier shown in Figure 6, given that r'_e is 25 ohms, is closest to:
 - a. 150
 - b. 37.6
 - c. 23.5
 - d. 2.2
49. The output voltage in Figure 6, with all switches closed, assuming a Z_{in} of 10 K, and an r'_e of 25 ohms, will equal:
 - a. 2.4 volts.
 - b. 0.6 volts.
 - c. 0.3 volts.
 - d. 12 volts.

50. A set of output or collector characteristic curves can be used to determine:
- ac beta.
 - dc beta.
 - optimum operating point.
 - all of the above.
51. The ac beta of a transistor is determined from:
- $\Delta I_B / \Delta I_C$.
 - I_C / I_B .
 - $\Delta I_C / \Delta I_B$.
 - none of the above.

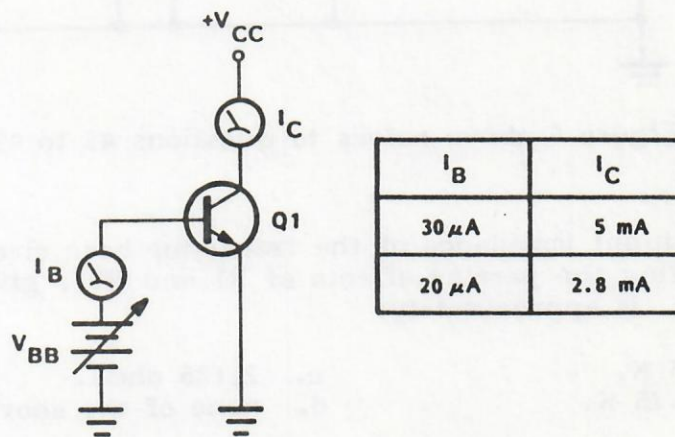


Figure 7 above refers to question 52.

52. For the readings shown in the chart in Figure 7, the ac beta for transistor Q1 is:
- 220.
 - 166.
 - 144.
 - none of the above.
53. A load line is to be plotted for a CE amplifier with a V_{CC} of 20 volts and an R_C of 2 K. The X and Y intercept points are:
- X = 10 mA; Y = 20 V.
 - X = 10 mA; Y = 10 V.
 - X = 20 V; Y = 10 mA.
 - none of the above.
54. The input resistance of a CC amplifier is:
- very low.
 - the same as a CE.
 - equal to $\beta(R_{in})$.
 - none of the above.
55. The phase difference between the input and output signals of a CC amplifier is:
- 0° .
 - 90° .
 - 180° .
 - 270° .

56. The output impedance of a CC amplifier is:
- very low.
 - the same as a CE.
 - equal to $\beta(R_E)$.
 - none of the above.
57. A darlington amplifier circuit is most useful because its:
- output impedance is high.
 - current gain is very low.
 - voltage gain is very high.
 - none of the above.
58. The darlington amplifier circuit is most useful when it is:
- being driven by a high impedance signal source.
 - driving a high impedance load.
 - being driven by a low impedance signal source.
 - none of the above.

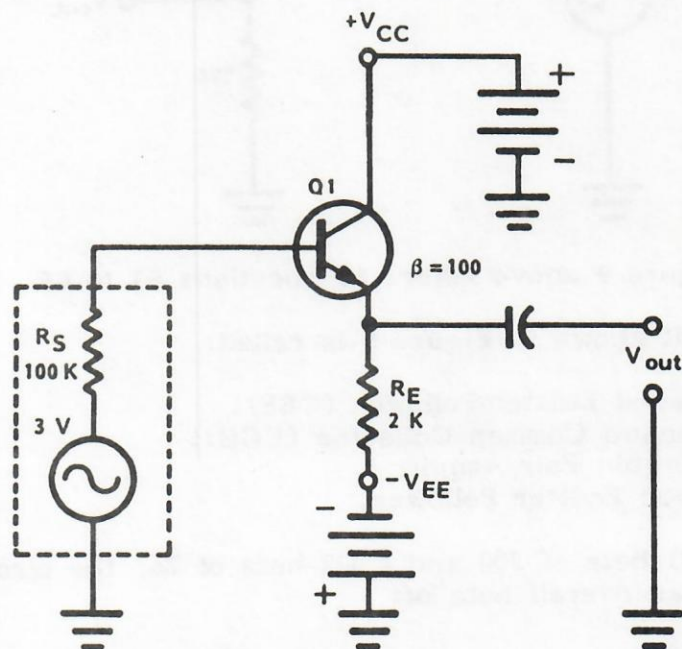


Figure 8 above refers to questions 59 to 62.

59. The amplifier circuit shown in Figure 8 is called a (an):
- common emitter.
 - emitter follower.
 - common collector.
 - either b or c.
60. The input impedance at the base of Q1 in Figure 8 is approximately:
- 100 K.
 - 100 ohms.
 - 200 K.
 - 2000 ohms.

61. The voltage gain of the circuit in Figure 8 is:
- approximately 1.
 - found from R_E/R_S .
 - found from R_S/R_E .
 - approximately 100.
62. The current gain of the circuit in Figure 8 is:
- 100.
 - 50.
 - 1.
 - 1.5 mA.

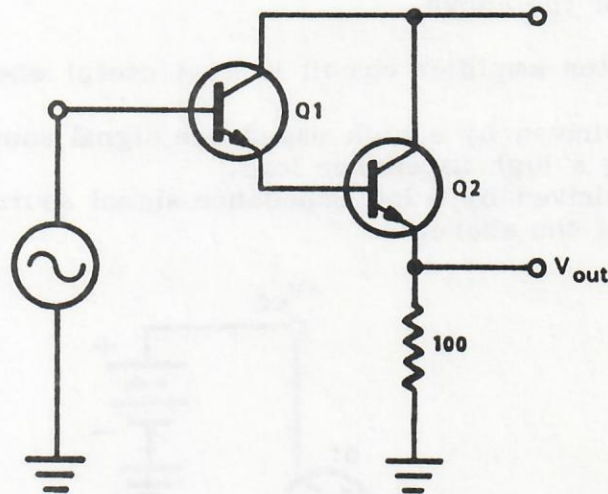


Figure 9 above refers to questions 63 to 65.

63. The circuit shown in Figure 9 is called:
- Cascaded Emitter Follower (CEF).
 - Compound Common Collector (CCC).
 - Darlington Pair Amplifier.
 - Common Emitter Follower.
64. Given a Q1 beta of 200 and a Q2 beta of 75, the circuit in Figure 9 produces an overall beta of:
- 15,000.
 - 275.
 - 125.
 - none of the above.
65. The input generator in Figure 9 will see a Z_{in} of approximately:
- 1.5 megohms.
 - 25 K.
 - 15 K.
 - 40 K.
66. In the common base circuit, the input impedance is _____ and the output impedance is _____.
- high; low.
 - low; high.
 - low; low.
 - high; high.

67. In the common base amplifier circuit, the voltage gain is _____ and the current gain is _____.
- high; high.
 - low; low.
 - low; high.
 - high; low.
68. In the common base amplifier circuit, the input signal and the output signal are:
- of equal amplitude
 - in phase.
 - 180° out of phase.
 - none of the above.
69. The major drawback of the common base circuit is its:
- low voltage gain.
 - high input impedance.
 - high voltage gain.
 - low input impedance.

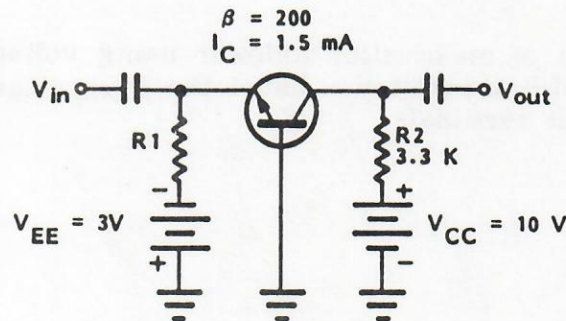


Figure 10 above refers to questions 70 and 71.

70. The value of $R1$ required to set I_E , and thus I_C also, at 1.5 mA in Figure 10 is:
- 3.3 K .
 - 2 K .
 - 1 K ohms .
 - 166 ohms .
71. Given a value of 2 K for $R1$ in Figure 10, the input impedance seen at the input terminal by the signal source is approximately:
- 17 ohms .
 - 2.0 K .
 - 2.37 K .
 - 3.3 K .
72. A transistor has a P_D rating of 450 mW at 25°C and a derating factor of $5\text{ mW}/^\circ\text{C}$. The maximum allowable P_D at 33°C is:
- 410 mW .
 - 525 mW .
 - 470 mW .
 - 505 mW .

73. The breakdown voltage between the base and the collector with the emitter open, is indicated by:
- a. I_{CBO} .
 - b. I_{CBS} .
 - c. $V_{BR\ ICEO}$.
 - d. none of the above.
74. A transistor has an f_T of 250 MHz, a beta of 100, an alpha of 0.99 and a P_D of 350 mW. The value of f_β is closest to:
- a. 250 MHz.
 - b. 350 MHz.
 - c. 2.5 MHz.
 - d. none of the above.
75. Given an f_β of 2.95 MHz for a transistor with a beta of 90, the transistor frequency response at unity is:
- a. 265.5 MHz.
 - b. 92.95 MHz.
 - c. 462.5 MHz.
 - d. none of the above.
76. Draw the circuit of an emitter follower using voltage divider biasing and a PNP transistor. Label the V_{CC} polarity and the input and output terminals.
77. Draw the circuit of an NPN transistor in a CE configuration using Collector Feedback bias. Label the polarity of V_{CC} and the input and output terminals.

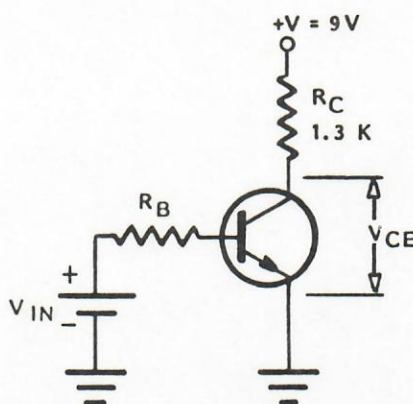


Figure 11 above refers to questions 78 to 80.

78. Calculate the X and Y intercepts points for the load line for the circuit of Figure 11 and plot the load line on the graph provided on the Answer Sheet. Show all calculations on the Answer Sheet.
79. Determine the quiescent values for I_C and V_{CE} given a base current of $15 \mu\text{A}$, using the data in Figure 11.
80. Using the data in Figure 11, calculate the swing in I_C and V_{CE} for a $10 \mu\text{A}$ p-p input current.



Figure 1: Circuit diagram for problem 10.

10. Calculate the open-circuit voltage v_{oc} and the short-circuit current i_{sc} for the circuit in Figure 1. Use the values $V_s = 10\text{ V}$, $R = 1\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$, $\beta = 100$, and $i_b = 1\text{ mA}$.
11. Determine the Thévenin voltage v_{th} and the Thévenin resistance R_{th} for the circuit in Figure 1. Use the values $V_s = 10\text{ V}$, $R = 1\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$, $\beta = 100$, and $i_b = 1\text{ mA}$.
12. Calculate the maximum average power P_{max} that can be delivered to the load resistor R_L in Figure 1. Use the values $V_s = 10\text{ V}$, $R = 1\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$, $\beta = 100$, and $i_b = 1\text{ mA}$.

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ANSWER SHEET—UNIT TEST J1

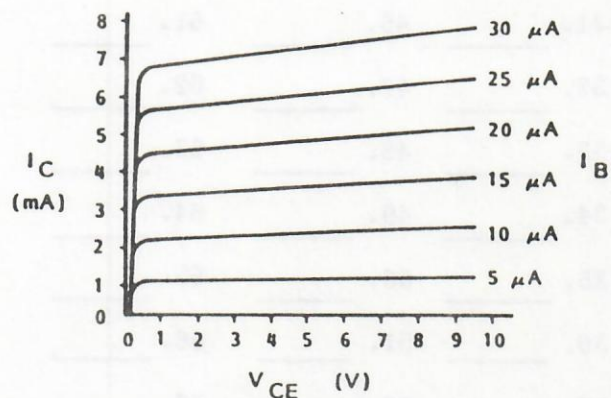
- | | | | | |
|-----------|-----------|-----------|-----------|-----------|
| 1. _____ | 16. _____ | 31. _____ | 46. _____ | 61. _____ |
| 2. _____ | 17. _____ | 32. _____ | 47. _____ | 62. _____ |
| 3. _____ | 18. _____ | 33. _____ | 48. _____ | 63. _____ |
| 4. _____ | 19. _____ | 34. _____ | 49. _____ | 64. _____ |
| 5. _____ | 20. _____ | 35. _____ | 50. _____ | 65. _____ |
| 6. _____ | 21. _____ | 36. _____ | 51. _____ | 66. _____ |
| 7. _____ | 22. _____ | 37. _____ | 52. _____ | 67. _____ |
| 8. _____ | 23. _____ | 38. _____ | 53. _____ | 68. _____ |
| 9. _____ | 24. _____ | 39. _____ | 54. _____ | 69. _____ |
| 10. _____ | 25. _____ | 40. _____ | 55. _____ | 70. _____ |
| 11. _____ | 26. _____ | 41. _____ | 56. _____ | 71. _____ |
| 12. _____ | 27. _____ | 42. _____ | 57. _____ | 72. _____ |
| 13. _____ | 28. _____ | 43. _____ | 58. _____ | 73. _____ |
| 14. _____ | 29. _____ | 44. _____ | 59. _____ | 74. _____ |
| 15. _____ | 30. _____ | 45. _____ | 60. _____ | 75. _____ |

76. _____

77. _____

NAME _____ CLASS _____ DATE _____

78.



Show all calculations.

79. Calculations; draw results on curves in question 78.

80. Calculations; draw results on curves in question 78.

Instructor's Answer Sheet
Unit Test
Transistors and Circuits
Part J1

Instructor's Answer Sheet

Unit Test

Transistors and Circuits

Part II

Unit Test

Part J1 — Transistors and Circuits

Instructor's Answer Sheet

1. d All of the above.
2. a The barrier potential developed across a silicon PN junction is approximately 0.7 volts.
3. b When a transistor is used as an amplifier, the B-E junction is forward biased and the B-C junction is reverse biased.
4. d All of the above.
5. a When an analog ohmmeter is connected across the B-E junction of a transistor and reads 250 K, it indicates that the junction is reverse biased.
6. c A transistor amplifier circuit normally operates in the linear region.
7. a In the circuit of Figure 1, moving the arm of R1 toward end A will cause the reading on M1 to increase and the reading on M2 to increase.
8. b If meters M2 and M3 in Figure 1 were accurate enough, the M3-M2 reading would be equal to I_B.
9. c When R1 in Figure 1 is adjusted so that meter M4 reads approximately 8 volts, the transistor is operating in the linear area.
10. b $I_C = 1.95 \text{ mA}; \quad \alpha = 0.975$
 $I_C = I_E - I_B = 2 - 0.05 = 1.95 \text{ mA}$
 $\alpha = I_C / I_B = 1.95 / 2 = 0.975$
11. b For the circuit shown in Figure 2, the value of r'_e is approximately 12.5 ohms.
$$r'_e = 25 / I_E = 25 / 2 = 12.5 \Omega$$
12. d The value of r'_e in Figure 2 is the same as H_{ib}.
13. b The circuit shown in Figure 2 has a voltage gain of 176.
$$A_v = \frac{R_C}{r'_e} = \frac{R_C}{(25 / I_E)} = \frac{2200}{(25 / 2)} = 176$$
14. b The phase relationship between the input and output signals of the amplifier shown in Figure 2 is 180 degrees.

UNIT TEST FOR PART J1 (ANSWERS)

15. a In the circuit of Figure 3, the emitter current, neglecting I_B , is approximately 2.5 mA.

$$I_E \cong I_C = \frac{V_{RC}}{R_C} = \frac{5.5}{2200} = 0.0025 \text{ A} = \underline{2.5 \text{ mA}}$$

16. d All of the above.

17. d The base current of Q1 in Figure 3 is closest to 22 μ A.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{11 - 0.7}{470 \times 10^3} = \underline{21.9 \mu\text{A}}$$

18. c Given a drop of 5.5 volts across R_C in Figure 3, the collector to emitter voltage is 5.5 volts.

$$V_{CE} = V_{CC} - V_{RC} = 11 - 5.5 = \underline{5.5 \text{ volts}}$$

19. c The maximum undistorted output voltage for Figure 3 can be achieved when the operating point is in the center of the linear operating region.

20. d All of the above.

21. b For the circuit of Figure 4, the voltage drop across R_C is 5 volts.

$$V_{RC} = V_{CC} - V_{CE} = 9 - 4 = \underline{5 \text{ V}}$$

22. c For the circuit of Figure 4, the collector current is 5 mA.

$$I_C = V_{RC} / R_C = 5 / 1000 = \underline{5 \text{ mA}}$$

23. b For the circuit of Figure 4, the base-emitter voltage is 0.7 volts.

$$V_{BE} = V_B - V_E = 1.2 - (100 \times 0.005) = \underline{0.7 \text{ V}}$$

24. b If the beta of the transistor in Figure 4 is 100, the base current flowing through R_B is 50 μ A.

$$I_B = I_C / \beta = 5 / 100 = \underline{50 \mu\text{A}}$$

25. a 29 mV

$$V_{in \text{ rms}} = \frac{V_{out \text{ pp}} (0.707)}{90 (2)} = \frac{7.5 (0.707)}{90 (2)} = \underline{0.029 \text{ V}}$$

26. a 0.5 V

$$V_{RE} = I_E R_E \cong I_C R_E = 0.005 (100) = \underline{0.5 \text{ V}}$$

UNIT TEST FOR PART J1 (ANSWERS)

27. c For the circuit of Figure 4, given a desired base current of $50 \mu\text{A}$, and that the transistor is a silicon type, the value of R_B should be approximately 156 K.

$$R_B = V_{CC} - V_B / I_B = 9 - 1.2 / 50 \times 10^{-6} = \underline{156 \text{ K}}$$

28. d All of the above.

29. c When selecting an operating point in a CE amplifier circuit that has a 1 volt drop across the emitter resistor and a V_{CC} of 15 volts, the ideal V_{CE} operating point is 7 volts.

$$V_{CE \text{ ideal}} = (V_{CC} - V_E) / 2 = (15 - 1) / 2 = \underline{7 \text{ volts}}$$

30. c The most stable bias circuit configuration is voltage divider bias.

31. a Emitter bias is not used often because it requires two voltage sources.

32. c Given a base current of $50 \mu\text{A}$ and a beta of 110 for a CE circuit, I_C is closest to 5.5 mA.

$$I_C = \beta I_B = 110 (0.05) = \underline{5.5 \text{ mA}}$$

33. b The voltage from emitter to ground in Figure 5 should be as close as possible to 1.2 volts, 10% of V_{CC} .

$$V_E = V_{CC} / 10 = 12 / 10 = \underline{1.2 \text{ volts}}$$

34. c The value of R_5 in Figure 5 should be 1000 ohms.

$$R_{E \text{ total}} = V_E / I_E = 1.2 / 0.001 = 1200 \quad R_5 = 1200 - 200 = \underline{1 \text{ K}}$$

35. b The value of R_2 in Figure 5 should be closest to 12 K.

$$R_2 = 10 R_{E \text{ total}} = 10(1,200) = \underline{12 \text{ K}}$$

36. c If Q_1 in Figure 5 is germanium, the voltage drop across R_2 is closest to 1.5 volts.

$$V_{R_2} = V_{BE} + V_E = 0.3 + 1.2 = \underline{1.5 \text{ volts}}$$

37. d The current flow through R_2 in Figure 5 is closest to 0.125 mA.

$$I_{R_2} = V_{R_2} / R_2 = 1.5 / 12 = \underline{0.125 \text{ mA}}$$

38. a The voltage drop across R_1 in Figure 5 is 10.5 volts.

$$V_{R_1} = V_{CC} - V_{R_2} = 12 - 1.5 = \underline{10.5 \text{ volts}}$$

UNIT TEST FOR PART J1 (ANSWERS)

39. c The best design value for the voltage drop across R3 in Figure 5 is 5.4 volts.

$$V_{R3} = (V_{CC} - V_E)/2 = (12 - 1.2)/2 = \underline{5.4 \text{ volts}}$$

40. a The ideal value for R3 in Figure 5 is 5.4 K.

$$R3 = V_{R3} / I_C = 5.4 / 0.001 = \underline{5,400 \Omega}$$

41. c The voltage gain of the amplifier in Figure 5 is 24.

$$A_v = R_C / (R4 + r'e) = 5400 / (200 + (25/1)) = \underline{24}$$

42. c The voltage gain for the circuit of Figure 5, when C3 is removed, will change to 4.4.

$$A_v = R_C / (R_{E \text{ total}} + r'e) = 5400 / (1200 + 25) = \underline{4.4}$$

43. a If capacitor C3 were disconnected from the junction of R4 and R5, in Figure 5, and connected to the emitter, the gain would increase to 216.

$$A_v = R_C / r'e = 5400 / 25 = \underline{216}$$

44. d All of the above.

45. b The ac input impedance of the transistor base circuit in Figure 6 (neglecting the parallel effects of R1 and R2), given that r'e is 25 ohms, is approximately 18.75 K.

$$Z_{in \text{ (base)}} = \beta (R_D + r'e) = 150 (100 + 25) = \underline{18,750 \Omega}$$

46. c The input impedance Z_{in} , as seen by the input generator in Figure 6, is approximately 8 K.

$$Z_{in} = Z_{in \text{ (base)}} // R1 // R2 = 18.75K // 47K // 20K = \underline{8K}$$

47. d Given an input impedance of 10K at point A in Figure 6 and an unloaded source voltage of 0.3 volts, the signal voltage at point A, when switch SA is closed, will be approximately 0.2 volts.

$$V_{in} = (V_S) \frac{Z_{in}}{R_S + Z_{in}} = (0.3) \frac{10}{5 + 10} = \underline{0.2 \text{ volts}}$$

48. b The theoretical unloaded gain of the amplifier shown in Figure 6, given that r'e is 25 ohms is closest to 37.6.

$$A_v = R_C / (R_D + R_E) = 4700 / (100 + 25) = \underline{37.6}$$

UNIT TEST FOR PART J1 (ANSWERS)

49. a The output voltage in Figure 6, with all switches closed, assuming a Z_{in} of 10K and an $r'e$ of 25 ohms, will equal 2.4 volts.

$$V_{in} = 0.2 \text{ volts as in Q.49; } R_{C \text{ eff}} = R_C // R_L = 4.7 // 2.2 = 1.5 \text{ K}$$

$$A_v = R_{C \text{ eff}} / (R_D + r'e) = 1500 / 125 = 12$$

$$V_{out} = A_v V_{in} = 12(0.2) = \underline{2.4 \text{ V}}$$

50. d All of the above.

51. c The ac beta of a transistor is determined from $\Delta I_C / \Delta I_B$.

52. a For the readings shown in the chart of Figure 7, the ac beta for transistor Q1 is 220.

$$\beta = \Delta I_C / \Delta I_B = (5 - 2.8) / (0.03 - 0.02) = 2.2 / .01 = \underline{220}$$

53. c A load line is to be plotted for a CE amplifier with a V_{CC} of 20 volts and an R_C of 2 K. The X and Y intercepts are X = 20 V; Y = 10 mA.

$$X = V_{CC} = \underline{20 \text{ V}}$$

$$Y = V_{CC} / R_C = 20 / 2000 = \underline{10 \text{ mA}}$$

54. b The input resistance of a CC amplifier is the same as a CE. (βR_E)

55. a The phase difference between the input and output signals of a CC amplifier is 0°.

56. a The output impedance of a CC amplifier is very low.

57. d None of the above.

58. a The darlington amplifier circuit is most useful when it is being driven by a high impedance, signal source.

59. d The amplifier circuit shown in Figure 8 is called an emitter follower or a common collector.

60. c The input impedance at the base of Q1 in Figure 8 is approximately 200 K.

$$R_{in} = \beta R_E = (100)(2000) = \underline{200,000 \Omega}$$

61. a The voltage gain of the circuit in Figure 8 is approximately 1.

62. a The current gain of the circuit in Figure 8 is approximately equal to 100 (beta).

63. c The circuit shown in Figure 9 is called a Darlington Pair Amplifier.

64. a Given a Q1 beta of 200 and a Q2 beta of 75, the circuit in Figure 9 produces an overall beta of 15,000.

UNIT TEST FOR PART J1 (ANSWERS)

65. a The input generator in Figure 9 will see a Z_{in} of approximately 1.5 megohms.

$$Z_{in} = (\beta_{Q1})(\beta_{Q2})(R_E) = (200)(75)(100) = \underline{1,500,000 \Omega}$$

66. b In the common base amplifier circuit, the input impedance is low and the output impedance is high.
67. d In the common base amplifier circuit, the voltage gain is high and the current gain is low.
68. b In the common base amplifier circuit, the input signal and output signal are in phase.
69. d The major drawback of the common base circuit is its low input impedance.
70. b The value of R_1 required to set I_E , and thus I_C also, at 1.5 mA in Figure 10 is 2 K.

$$R_1 = V_{EE} / I_E = 3 / 0.0015 = \underline{2000 \Omega}$$

71. a Given a value of 2 K for R_1 in Figure 10, the input impedance seen at the input terminal by the signal source is approximately 17 ohms.

$$Z_{in} = R_1 // r'_e = 2000 // (25 / 1.5) = \underline{16.66 \Omega}$$

72. a A transistor has a P_D rating of 450 mW at 25°C and a derating factor of 5 mW/°C. The maximum allowable P_D at 33°C is 410 mW.

$$\text{Derated } P_D = 450 - (5 (33 - 25)) = 450 - 40 = \underline{410 \text{ mW}}$$

73. d The breakdown voltage between the base and the collector with the emitter open, is indicated by $V_{BC \text{ CBO}}$.
74. c A transistor has an f_T of 250 MHz, a beta of 100, an alpha of 0.99 and P_D of 350 mW. The value of f_β is closest to 2.5 MHz.

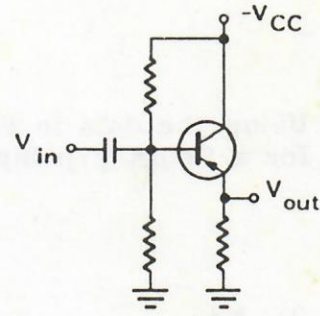
$$f_\beta = f_T / \beta = 250 \text{ MHz} / 100 = \underline{2.5 \text{ MHz}}$$

75. a Given an f_β of 2.95 MHz for a transistor with a beta of 90, the transistor frequency response at unity is 265.5 MHz.

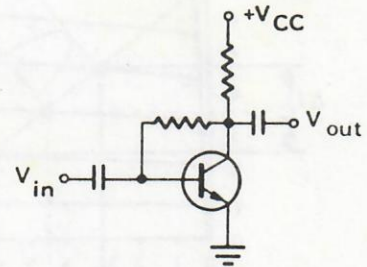
$$f_{\text{unity}} = f_T = f_\beta (\beta) = 2.95 \text{ MHz} (90) = \underline{265.5 \text{ MHz}}$$

UNIT TEST FOR PART J1 (ANSWERS)

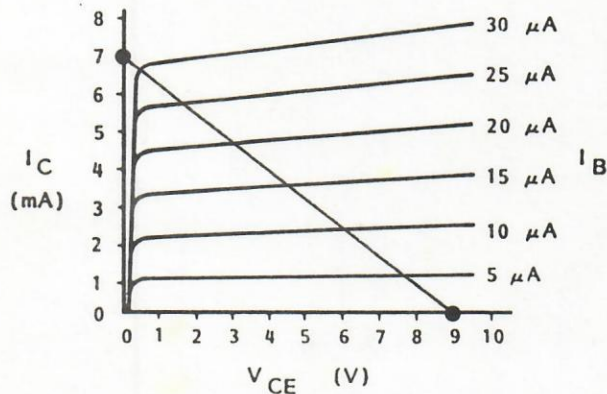
76. Draw the circuit of an emitter follower using voltage divider biasing and a PNP transistor. Label the V_{CC} polarity and input and output terminals.



77. Draw the circuit of an NPN transistor in a CE configuration using Collector Feedback bias. Label the V_{CC} polarity and the input and output terminals.



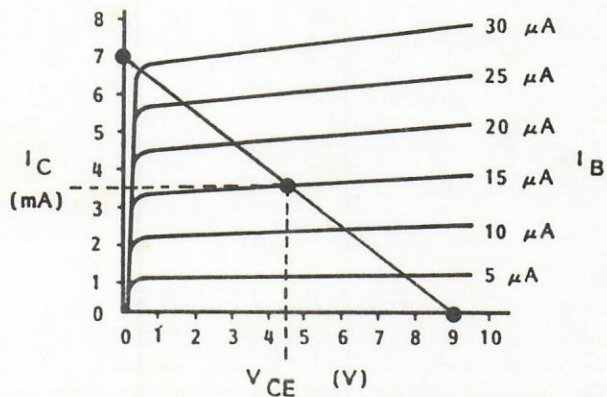
78. Calculate the X and Y intercept points for the load line on the graph. Show all calculations.



$$X \text{ intercept} = V_{CC} = \underline{9 \text{ V}}$$

$$Y \text{ intercept} = V_{CC} / R_C \\ = 9 / 1300 \\ = 0.007 \text{ A} = \underline{7 \text{ mA}}$$

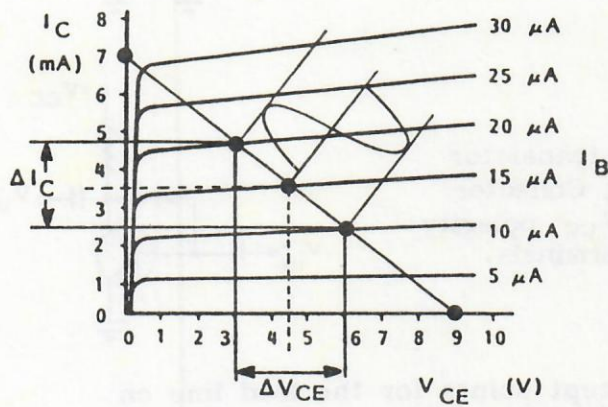
79. Determine the quiescent values for I_C and V_{CE} given a base current of $15 \mu\text{A}$ using the data in Figure 11.



$$I_C = \underline{3.5 \text{ mA}} \\ V_{CE} = \underline{4.5 \text{ V}}$$

UNIT TEST FOR PART J1 (ANSWERS)

80. Using the data in Figure 11, calculate the swing in I_C and V_{CE} for a $10\ \mu\text{A}$ p-p input current.

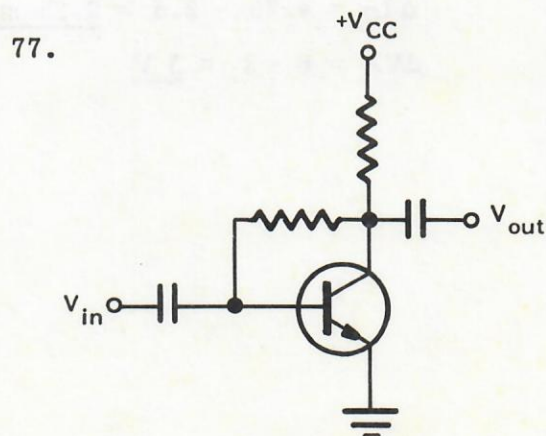
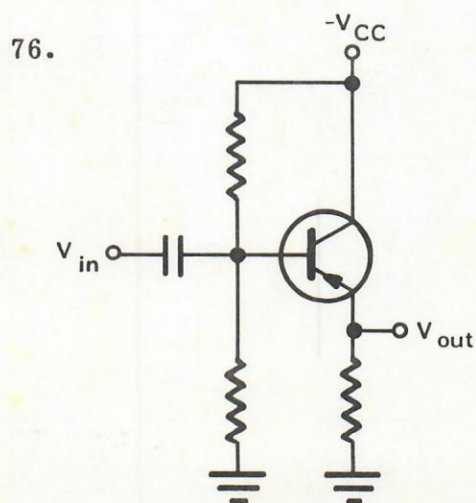


$$\Delta I_C = 4.75 - 2.5 = \underline{2.25\ \text{mA}}$$

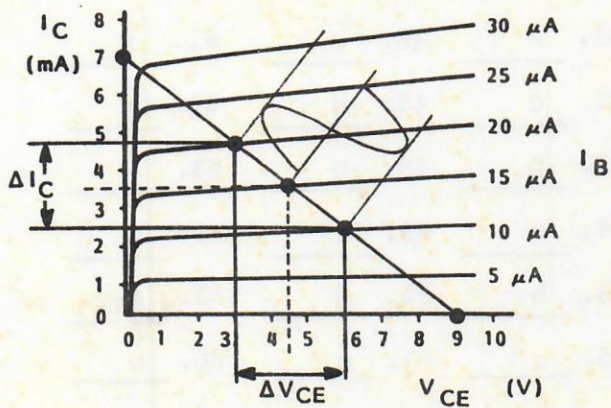
$$\Delta V_{CE} = 6 - 3 = \underline{3\ \text{V}}$$

ANSWER SHEET—UNIT TEST J1

- | | | | | |
|--------------|--------------|--------------|--------------|--------------|
| 1. <u>d</u> | 16. <u>d</u> | 31. <u>a</u> | 46. <u>c</u> | 61. <u>a</u> |
| 2. <u>a</u> | 17. <u>d</u> | 32. <u>c</u> | 47. <u>d</u> | 62. <u>a</u> |
| 3. <u>b</u> | 18. <u>c</u> | 33. <u>b</u> | 48. <u>b</u> | 63. <u>c</u> |
| 4. <u>d</u> | 19. <u>c</u> | 34. <u>c</u> | 49. <u>a</u> | 64. <u>a</u> |
| 5. <u>a</u> | 20. <u>d</u> | 35. <u>b</u> | 50. <u>d</u> | 65. <u>a</u> |
| 6. <u>c</u> | 21. <u>b</u> | 36. <u>c</u> | 51. <u>c</u> | 66. <u>b</u> |
| 7. <u>a</u> | 22. <u>c</u> | 37. <u>d</u> | 52. <u>a</u> | 67. <u>d</u> |
| 8. <u>b</u> | 23. <u>b</u> | 38. <u>a</u> | 53. <u>c</u> | 68. <u>b</u> |
| 9. <u>c</u> | 24. <u>b</u> | 39. <u>c</u> | 54. <u>b</u> | 69. <u>d</u> |
| 10. <u>b</u> | 25. <u>a</u> | 40. <u>a</u> | 55. <u>a</u> | 70. <u>b</u> |
| 11. <u>b</u> | 26. <u>a</u> | 41. <u>c</u> | 56. <u>a</u> | 71. <u>a</u> |
| 12. <u>d</u> | 27. <u>c</u> | 42. <u>c</u> | 57. <u>d</u> | 72. <u>a</u> |
| 13. <u>b</u> | 28. <u>d</u> | 43. <u>a</u> | 58. <u>a</u> | 73. <u>d</u> |
| 14. <u>b</u> | 29. <u>c</u> | 44. <u>d</u> | 59. <u>d</u> | 74. <u>c</u> |
| 15. <u>a</u> | 30. <u>c</u> | 45. <u>b</u> | 60. <u>c</u> | 75. <u>a</u> |



78.



Show all calculations.

$$\text{X intercept} = V_{CC} = \underline{9 \text{ V}}$$

$$\text{Y intercept} = V_{CC} / R_C$$

$$= 9 / 1300$$

$$= 0.007 \text{ A} = \underline{7 \text{ mA}}$$

79. Calculations; draw results on curves in question 78.

$$I_C = \underline{3.5 \text{ mA}}$$

$$V_{CE} = \underline{4.5 \text{ V}}$$

80. Calculations; draw results on curves in question 78.

$$\Delta I_C = 4.75 - 2.5 = \underline{2.25 \text{ mA}}$$

$$\Delta V_C = 6 - 3 = \underline{3 \text{ V}}$$